NAVY
PROPOSAL SUBMISSION
INTRODUCTION

The responsibility for the implementation, administration and management of the Navy SBIR program is with the Office of Naval Research (ONR). The Navy SBIR Program Manager is Mr. Vincent D. Schaper, (703) 696-8528. The Deputy SBIR Program Manager is Mr. John Williams, (703) 696-3042. For technical questions about the topic, contact the Topic Authors listed under each topic on the website before **1 July 2002.** For general inquiries or problems with the electronic submission, contact the DoD Help Desk at 1-866-724-7457 (8AM to 5PM EST).

The Navy's SBIR program is a mission-oriented program that integrates the needs and requirements of the Navy's Fleet through R&D topics that have dual-use potential, but primarily address the needs of the Navy. Information on the Navy SBIR Program can be found on the Navy SBIR website at **http://www.onr.navy.mil/sbir**. Additional information pertaining to the Department of the Navy's mission can be obtained by viewing the website at **http://www.navy.mil**.

PHASE I PROPOSAL SUBMISSION:

Read the DoD front section of this solicitation for detailed instructions on proposal format and program requirements. When you prepare your proposal, keep in mind that Phase I should address the feasibility of a solution to the topic. The Navy only accepts Phase I proposals with a base effort not exceeding $70,000 and with the option not exceeding $30,000. The technical period of performance for the Phase I should be 6 months and for the Phase I option should be 3 months. The Phase I option should address the transition into the Phase II effort. Phase I options are typically only funded after the decision to fund the Phase II has been made. Phase I proposals, including the option, have a 25-page limit (see section 3.3). The Navy will evaluate and select Phase I proposals using scientific review criteria based upon technical merit and other criteria as discussed in this solicitation document. Due to limited funding, the Navy reserves the right to limit awards under any topic and only proposals considered to be of superior quality will be funded. The Navy typically provides a firm fixed price contract or awards a small purchase agreement as a Phase I award.

It is mandatory that the **entire** technical proposal, DoD Proposal Cover Sheet, Cost Proposal, and the Company Commercialization Report are submitted electronically through the DoD SBIR website at **http://www.dodsbir.net/submission**. If you have any questions or problems with the electronic submission contact the DoD SBIR Helpdesk at 1-866-724-7457 (8AM to 5PM EST).

TOPIC N02-207. **Broad Anti-Terrorism Topic. If you have any thoughts about solutions to problems about detection, survivability, consequence management, or attribution resulting from an attack on any Naval forces, please read Topic N02-207.**

NEW REQUIREMENT: ALL PROPOSAL SUBMISSIONS TO THE NAVY SBIR PROGRAM MUST BE SUBMITTED ELECTRONICALLY

Complete electronic submission includes the submission of the Cover Sheets, Cost Proposal, Company Commercialization Report, the **ENTIRE** technical proposal and any appendices via the DoD Submission site. The DoD proposal submission site **http://www.dodsbir.net/submission** will lead you through the process for submitting your technical proposal and all of the sections electronically. Each of these documents are submitted separately through the website. Your proposal must be submitted via the submission site on or before the **3:00 p.m. local time, 14 August 2002** deadline. A hardcopy will NOT be required. A signature by hand or electronically is not required when you submit your proposal over the Internet.

Acceptable Formats for Online Submission: All technical proposal files will be converted to Portable Document Format (PDF) for evaluation purposes – do not lock/protect your pdf file; therefore, submissions may be received in PDF format but other acceptable formats are MS Word, WordPerfect, Text, Rich Text Format (RTF), and Adobe Acrobat. The Technical Proposal should include all graphics and attachments, but not include Cover Sheets. You are required to include your company name and topic number as a header in your technical proposal document. Cost sheets can be included in the technical proposal or submitted separately through the form available through this website. Technical Proposals should conform to the limitations on margins and number of pages specified in the front section of this DoD Solicitation. However, your Cost Proposal will only count as one page and your Cover Sheets will only count as two, no matter how they print out after being converted. Most proposals will be printed out on black and white printers so make sure all graphics are distinguishable in black and white. It is strongly encouraged that you perform a virus check on each submission to avoid complications or delays in downloading your Technical Proposal. To verify that your proposal has been received, click on the "Check Upload" icon to view your proposal. Typically, your proposal will be uploaded within the hour. However, if your proposal does not appear after an hour, please contact the DoD Help Desk. It is recommended that you submit early, as computer traffic gets heavy nearer the solicitation closing and slows down the system.

Within one week of the Solicitation closing, you will receive notification via e-mail that your proposal has been received and processed for evaluation by the Navy. Please make sure that your e-mail address is entered correctly on your proposal coversheet or you will not receive a notification.

PHASE I ELECTRONIC FINAL REPORT:

All Phase I award winners must electronically submit a Phase I summary report through the Navy SBIR website at the end of their Phase I. The Phase I Summary Report is a non-proprietary summary of Phase I results. It should not exceed 700 words and should include potential applications and benefits. It should require minimal work from the contractor because most of this information is required in the final report. The summary of the final report will be submitted through the Navy SBIR/STTR website at: **http://www.onr.navy.mil/sbir**, click on "Submission", then click on "Submit a Phase I or II Summary Report".

ADDITIONAL NOTES:

The Small Business Administration (SBA) has made a determination that will permit the Naval Academy, the Navy Post Graduate School and the other military academies to participate as subcontractors in the SBIR/STTR program, since they are institutions of higher learning.

The Navy will allow firms to include with their proposals, success stories that have been submitted through the Navy SBIR website at **http://www.onr.navy.mil/sbir**. A Navy success story is any follow-on funding that a firm has received based on technology developed from a Navy SBIR or STTR Phase II award. The success stories should be included as appendices to the proposal. These pages will not be counted towards the 25-page limit. The success story information will be used as part of the evaluation of the third criteria, Commercial Potential (listed in Section 4.2 of this solicitation) which includes the Company's Commercialization Report and the strategy described to commercialize the technology discussed in the proposal. The Navy is very interested in companies that transition SBIR efforts directly into Navy and DoD programs and/or weapon systems. If a firm has never received a Navy SBIR Phase II it will not count against them. Phase III efforts should also be reported to the Navy SBIR program office noted above.

NAVY FAST TRACK DATES AND REQUIREMENTS:

The Fast Track application must be received by the Navy 150 days from the Phase I award start date. Your Phase II Proposal must be submitted within 180 days of the Phase I award start date. Any Fast Track applications or proposals not meeting these dates may be declined. All Fast Track applications and required information must be sent to the Navy SBIR Program Manager at the address listed above, to the designated Contracting Officer's Technical Monitor (the Technical Point of Contact (TPOC)) for the contract, and the appropriate Navy Activity SBIR Program Manager listed in Table 1 of this Introduction. The information required by the Navy, is the same as the information required under the DoD Fast Track described in the front part of this solicitation.

PHASE II PROPOSAL SUBMISSION:

Phase II is the demonstration of the technology that was found feasible in Phase I. Only those Phase I awardees which have been **invited** to submit a Phase II proposal by that Activity's proper point of contact, listed in Table 1, during or at the end of a successful Phase I effort will be eligible to participate for a Phase II award. If you have been invited to submit a Phase II proposal to the Navy, obtain a copy of the Phase II instructions from the Navy SBIR website or request the instructions from the Navy Activity POC listed in Table 1. The Navy will also offer a "Fast Track" into Phase II to those companies that successfully obtain third party cash partnership funds ("Fast Track" is described in Section 4.5 of this solicitation). The Navy typically provides a cost plus fixed fee contract or an Other Transition Agreement (OTA) as a Phase II award. The type of award is at the discretion of the contracting officer.

Upon receiving an invitation, submission of a Phase II proposal should consist of three elements: 1) A base effort, which is the demonstration phase of the SBIR project; 2) A separate 2 to 5 page Transition/Marketing plan (formerly called a "commercialization plan") describing how, to whom and at what stage you will market and transition your technology to the government, government prime contractor, and/or private sector; and 3) At least one Phase II Option which would be a fully costed and well defined section describing a test and evaluation plan or further R&D. Phase II efforts are typically two (2) years and Phase II options are typically an additional six (6) months. **Each of the Navy Activities have different award amounts and schedules; you are required to get specific guidance from that Activity's SBIR Program Manager before submitting your Phase II proposal**. Phase II proposals together with the Phase II Option are limited to 40 pages (unless otherwise directed by the TPOC or contract officer). The Transition/Marketing plan must be a separate document that is submitted through the Navy SBIR website at **http://www.onr.navy.mil/sbir** under "Submission" and also included with the proposal submission online. All Phase II proposals must have a complete electronic submission. Complete electronic submission includes the submission of the Cover Sheets, Cost Proposal, Company Commercialization Report, the **ENTIRE** technical proposal and any appendices via the DoD Submission site. The DoD proposal submission site **http://www.dodsbir.net/submission** will lead you through the process for submitting your technical proposal and all of the sections electronically. Each of these documents are submitted separately through the website. Your proposal must be submitted via the submission site on or before the Navy Activity specified deadline. The Navy Activity that invited your PH II may also require a hardcopy or your proposal.

All Phase II award winners must attend a one-day Commercialization Assistance Program (CAP) meeting typically held in the July to August time frame in the Washington D.C. area during the second year of the Phase II effort. If you receive a Phase II award, you will be contacted with more information regarding this program or you can visit **http://www.navysbir.com/cap**.

As with the Phase I award, Phase II award winners must electronically submit a Phase II summary report through the Navy SBIR website at the end of their Phase II. The Phase II Summary Report is a non-proprietary summary of Phase II results. It should not exceed 700 words and should include potential applications and benefit. It should require minimal work from the contractor because most of this information is required in the final report.

The Navy has adopted a New Phase II Enhancement Plan to encourage transition of Navy SBIR funded technology to the Fleet. Since the Law (PL102-564) permits Phase III awards during Phase II work, the Navy will provide a 1 to 4 match of Phase II to Phase III funds that the company obtains from an acquisition program. Up to $250,000 in additional SBIR funds for $1,000,000 match of acquisition program funding, can be provided as long as the Phase III is awarded and funded during the Phase II. If you have questions, please contact the Navy Activity POC.

Effective in Fiscal Year 2000, a Navy Activity will not issue a Navy SBIR Phase II award to a company when the elapsed time between the completion of the Phase I award and the actual Phase II award date is eight (8) months or greater; unless the process and the award has been formally reviewed and approved by the Navy SBIR Program Office. Also, any SBIR Phase I contract that has been extended by a no cost extension beyond one (1) year will be ineligible for a Navy SBIR Phase II award using SBIR funds.

PHASE III

Public Law 106-554 provided for protection of SBIR data rights under SBIR Phase III awards. A Phase III SBIR award is any contract or grant where the technology is the same as, derived from, or evolved from a Phase I or a Phase II SBIR/STTR contract and awarded to the company which was awarded the Phase I/II SBIR. This covers any contract/grant issued as a follow-on Phase III SBIR award or any contract/grant award issued as a result of a competitive process where the awardee was an SBIR firm that developed the technology as a result of a Phase I or Phase II SBIR. The Navy **will** give SBIR Phase III status to any award that falls within the above-mentioned description. The governments prime contractors and/or their subcontractors will follow the same guidelines as above and ensure that companies operating on behalf of the Navy protect data rights of the SBIR company.

TABLE 1. NAVY ACTIVITY SBIR PROGRAM MANAGERS POINTS OF CONTACT (POC) FOR TOPICS

Topic Numbers	Point of Contact	Activity	Phone
N02-115 through N02-122	Mr. Rod Manzano	MARCOR	703-432-3295
N02-123 through N02-140	Mr. Dick Milligan	NAVSEA	202- 781-3747
N02-141 through N02-195	Mrs. Carol Van Wyk	NAVAIR	301-342-0215
N02-196 through N02-204 & N02-207	Mr. Douglas Harry	ONR	703-696-4286
N02-205 through N02-206	Mr. Charles Marino	SSP	202-764-1553

Do not contact the Program Managers for technical questions. For technical questions, please contact the topic authors during the pre-solicitation period from 1 May 2002 until 1 July 2002. These topic authors are listed on the Navy website under "Solicitation" or the DoD website. After 1 July, you must use the SITIS system listed in section 1.5c at the front of the solicitation or go to the DoD website for more information.

PHASE I PROPOSAL SUBMISSION CHECKLIST:

All of the following criteria must be met or your proposal will be REJECTED.

____1. Make sure you have added a header with company name and topic number to each page of your technical proposal.

____2. Your technical proposal has been uploaded. The DoD Proposal Cover Sheet, the DoD Company Commercialization Report, and the Cost Proposal have been submitted electronically through the DoD submission site by 3:00 p.m. EST 14 August 2002.

____3. After uploading your file and it is saved on the DoD submission site as a PDF file, review it to ensure that it appears correctly.

____4. The Phase I proposed cost for the base effort does not exceed $70,000. The Phase I Option proposed cost does not exceed $30,000. The costs for the base and option are clearly separate, and identified on the Proposal Cover Sheet, in the cost proposal, and in the work plan section of the proposal.

NAVY 02.2 SBIR TITLE INDEX

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N02-115 Affordable Hybrid Drive System for Small to Medium Sized Unmanned Ground Vehicles (UGV)
N02-116 Canine Explosive Scent Kit Inert Replacements
N02-117 Disposable Chemical Detection
N02-118 Individual Bio Sensor / Sampler
N02-119 Non-Lethal Area Denial to Personnel
N02-120 Omni-Vision System for Day/Night Unmanned Ground Vehicle (UGV) Reconnaissance, Surveillance, and Target Acquisition (RSTA)/Mobility
N02-121 Personnel Neuromuscular Disruptor Incapacitation System
N02-122 Range Variable Non-Lethal Munitions

Naval Sea Systems Command (NAVSEA)

N02-123 Integrated System Design and Maintenance Modeling Tools for CBM
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N02-126 Free Space Optics Ship to Ship Network Communication Capability
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N02-128 Highly Effective EM Shielding Technique for Ship Composite Structures
N02-129 Shipboard Applications of Near Frictionless Carbon (NFC
N02-130 Barrel Coating and Liners for Extended Barrel Life
N02-131 In-Bore Dynamic Instrumentation for Navy Gun Barrels
N02-132 Autonomous Prescription of Maintenance Requirements
N02-133 Sensorless Control of Linear Motors
N02-134 High Density Electric Energy Storage
N02-135 Aircraft Carrier Environmental Maintenance Enclosure
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N02-137 Integrated Information Architecture for Crisis Management and Response
N02-138 Automatic, Non-Intrusive Chemical, Biological, and Radiological (CBR) Threat Detection
N02-139 High Energy Solid State Laser (SSL) for Ship Self-Defense
N02-140 Design and Build a Revolutionary Phased Array Radar System

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N02-142 Low-Cost Laser Diodes for Navy Applications
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N02-149 High Fuel-Air Ratio (FAR) Combustor Modeling
N02-150 Mid-Air Collision Avoidance System (MCAS) Data Fusion Methods
N02-151 Passive Noise Reduction Technology to Improve Speech Intelligibility and Reduce Noise for Pilot and Deck Crew Helmet Mounted Systems
N02-152 Environmental Mission Planner – The Total Solution
N02-153 High-Efficiency Plasma Sparkers for Navy Applications
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N02-161 Hybrid Integrity for Precision Guidance and Landing
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N02-164 Precision Geo-Location for Turreted Electro-Optic Sensors

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N02-169	Innovative Gas Turbine Engine Propulsion
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N02-186	High Energy, Lightweight, Sealed Lead Acid Battery for V-22 Applications
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N02-191	Interface between Image Generator and Display
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N02-193	Leak Detectors in Aircraft Systems
N02-194	Fiber Placement Process Expert System
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Office of Naval Research (ONR)

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NAVY 02.2 SBIR TOPICS

N02-115 **TITLE:** Affordable Hybrid Drive System for Small to Medium Sized Unmanned Ground Vehicles (UGV)

TECHNOLOGY AREAS: Ground/Sea Vehicles

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: Unmanned Ground Vehicles/Systems Joint Project Office

OBJECTIVE: Enable 100-1000 pound UGVs to operate in rough terrain with minimal acoustic signature for extended periods of time at an affordable cost.

DESCRIPTION: Hybrid electric drive has proven viable in both military and commercial applications due to its excellent performance, reduced emissions, and low acoustic signature. Little or no work has been done to apply this technology to improve the stealth of small/medium robots. These systems require large amounts of torque to traverse obstacles as well as good speed, both requiring high power to weight. Current requirements for USMC systems need a drive system capable of propelling a 1000-pound vehicle with 300-pound payload at 35kph while acoustically undetectable at 50 meters. The system must accomplish a 24-hour mission (8 hours of movement at 15kph and 16 hours stationary powering RSTA payload with minimum engine operation). The system must accelerate up a 60% slope from a start. Similar requirements are expected for U.S. Army systems within the Future Combat Systems. Cost of the drive system must not adversely affect an AUPC of the entire system and is a significant driver.

PHASE I: Research current state of the art in hybrid mobility systems and develop a design for a drive system for a <1000-pound UGV (plus 300 pound payload). The design should include cost estimates for prototype development and assessment of production and technology risks. The system must be heavy fuel and comply with applicable military logistics considerations while minimizing weight and size impacts.

PHASE II: Develop two prototype mobility systems for test by UGV/S JPO. The prototypes may be controlled by simple commercial remote control.

PHASE III: Complete development, production, and integration of a quiet and capable drive system into the Gladiator program and other DOD robotic systems including Future Combat Systems and Man-Portable Robotic Systems. Also, possibly use the system for small manned transport such as motorcycles or mail carriers.

PHASE III DUAL USE APPLICATIONS: This system could be applied to any mobility platform in the civilian sector due to its emissions and noise reduction.

REFERENCES:

1. Robotic systems of this type are listed in the Joint Robotics Program Master Plan available at www.jointrobotics.com. Further information on Navy/USMC requirements include the Gladiator TUGV program technology effort, part of the Autonomous Operations Future Naval Capabilities program with information found at http://www.onr.navy.mil/auto-ops/.

KEYWORDS: Hybrid, Robot, Unmanned, Mobility, Electric, Power

N02-116 **TITLE:** Canine Explosive Scent Kit Inert Replacements

TECHNOLOGY AREAS: Materials/Processes

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: DEMOLITION Joint Project

OBJECTIVE: Develop inert replacements for the explosives that comprise the canine explosive scent kit. The kit currently consists of ten explosives of which the dynamite component, because of its limited shelf life, has to be replaced annually with fresh material. Inert replacements in addition to addressing the dynamite shelf life problem would also solve storage, logistics and safety issues associated with these demolition explosives.

DESCRIPTION: The canine explosive scent kit serves as a training aid for Military Working Dogs (MWD's) and their physical security teams, to be a first line of defense for detecting high explosives that are generally used in demolition operations and which have also become explosives of choice by terrorist operatives here and throughout the world. The current Navy kit consists of ten (10) explosives, which are, Water Gel explosive, Smokeless Powder, Composition C4, Time Blasting Fuse, Detonating

Cord, TNT, Dynamite, Emulsion Blasting Agent, Ammonium Nitrate/Fuel Oil (ANFO) and Semtex. Seven of these explosive scents comprise the standard DoD kit which is used to provide brand new MWD's their initial explosive training before graduating to Navy, Air Force, Army and Marine Corps field activities. As the years progressed, the threat scenario changed as the use of other high explosives emerged and thus increased the threat hazard at international, national and local levels of society. Hence the introduction of the latter three explosives into the scent kit is an attempt to keep the kit current with the present threat hazards that exist. Earlier kits consisted of two common types of dynamite; however, as commercial demand and availability for one of the types waned, so was its likelihood as a serious security threat. Hence it was eventually discontinued and replaced with another more prevalent explosive. Also, due to dynamite's limited shelf life, it has to be replaced every 12 to 18 months throughout the Navy and Marine Corps MWD units. This presents a significant dollar outlay in planning, procurement, preparation (kit assembly), shipping and ultimate disposal of the assets. Additionally, the component kits by their very nature as being hazardous pilferable materials, require extensive inventory control, physical or electronic surveillance and material accountability. These stringent security measures often impact the logistics of training, since truly effective training cannot be conducted in an open more realistic environment.

PHASE I: Determine formulation and scent signature of each explosive component to obtain baseline data. Develop inert simulant using an approach that is consistent with current practices used in coating inert substrate with very low concentrations of the explosive in question. The aim is to achieve an "inert" (or non-detonable) material with scent/odor signature identical to the explosive in question. Develop inert simulant using slurry coating approach that is consistent in manufacturing of explosive molding powders. Inert simulant should have same scent signature as explosive in question. Using current state of the art laboratory technique and processes, synthesize an inert material with same chemical base as the explosive in question and also with same scent signature.

Also during Phase I, we would like to develop a mechanical device/process (i.e. a vapor modulator) that can be used in conjunction with the accepted approach from above, to generate varying levels of "scent-strength" to allow MWD's to be trained to detect explosive vapors that vary in strength from a few pounds to 100 to 200 lbs of material in sheer quantity. One of the various approaches outlined above will be accepted for Phase II based on its "similarity" (scent characteristics) to its live explosive counterpart, cost effectiveness, and ease of transition to mass production.

PHASE II: Field test successful inert simulants using MWD's at the DoD's training facility to determine level of dog detection and adaptability to simulants in lieu of live explosive counterparts. DoD facilities and MWD's will be available at no cost to the contractor for testing. Perform aging and extensive handling tests on each successful replacement simulant to determine shelf life, durability, strength of smell as a function of repeated handling and interaction with other materials, and longevity.

PHASE III: Demonstrate mass producibilty and develop implementation plan for new production. Present results to members of the joint services.

PHASE III DUAL USE APPLICATIONS: Potential exists to market inert training aids to all local police departments throughout the United States, Law Enforcement and Physical Security teams of the US Army, Air Force, Navy, FAA, Border Patrol, US Customs, Marine Corps, Secret Service, Bureau of Alcohol, Tobacco and Firearms (BATF), and other Federal Security Forces that use canine explosive scent kits as part of their regular function. The Military and security forces of other countries such as Sweden, Australia, UK, etc., could benefit from these training aids as well

KEYWORDS: Inert, Training Aid, Scent Signature, Vapor, Simulants

N02-117 **TITLE:** Disposable Chemical Detection

TECHNOLOGY AREAS: Chemical/Bio Defense

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: NBC (Nuclear-Biological-Chemical)

OBJECTIVE: Allow real-time detection of low-level chemical exposures to select Toxic Industrial Compounds (TICs) for deployed U.S. Forces.

DESCRIPTION: Current deployments of U.S. Forces face chronic and acute environmental threats from the poor environmental practices of host nations, collateral damage from warfare, and terrorism. These threats consist of compounds that are not detectable by currently fielded systems [Automatic Chemical Agent Alarm (M22 ACADA), Remote Sensing Chemical Agent Alarm (M-21 RSCAAL), M256A-1 Chemical Agent Detection Kit, Chemical Agent Monitor (CAM)] or systems currently in development [Joint Chemical Agent Detector (JCAD), Joint Service Lightweight Standoff Chemical Agent Detector (JSLSCAD)]. The FOX NBC reconnaissance vehicle which, can detect some TICs, has a limited library and is not broadly deployed. Currently fielded protective equipment, Joint Service Lightweight Integrated Suit Technology (JSLIST) and M40 masks with C2A1 filter canisters, do not perform well against some common TICs. Early work undertaken in the Force Medical Protection Advanced Concept Technology Demonstration (FMP ACTD) indicates that some TICs will be very difficult to collect and analyze in a timely and cost effective manner using traditional industrial hygiene techniques. These compounds may lend themselves to non-analytical colormetric detection however. Current commercial products of this nature are expensive, must be stored in refrigeration, detect only one compound at a time and are designed for short sampling periods usually less than 12 hours. If a concerted effort is made, a field supportable, individual, passive sampling, multi-agent, colormetric badge could be developed. The badge would be approximately two inches square, weighing 1 ounce and could detect several compounds at once. The target compounds for the badges could be tailored for each mission based on threat intelligence and would be selected to compliment the weaknesses of other detection technologies (Ion Mobility Spectroscopy, Surface Acoustic Wave, Gas Chromatography/Mass Spectroscopy, etc). This effort would address threats listed in International Task Force (ITF)-25 "Threat From Industrial Chemicals" and the U.S. Army's Center for Health Promotion and Preventive Medicine (USACHPPM) Technical Guide 230A "Short-Term Chemical Exposure Guidelines for Deployed Military Personnel". This effort would support Presidential Review Directive 5 "A National Obligation", Department of Defense Directive 6490.2 "Joint Medical Surveillance", Department of Defense Instruction 6490.3 "Implementation and Application of Joint Medical Surveillance for Deployments", and recommendations made in "Strategies to Protect the Health of Deployed U.S. Forces" published by the National Academy of Sciences.

PHASE I: Down select target compound list; Concepts for making system field rugged, weatherproof badge design; Assessment of colormetric chemistries and technology.

PHASE II: Construct prototype badges; Conduct laboratory testing for specificity, cross reactivity, temperature and humidity effects, shelf life and service life.

PHASE III: Produce sufficient quantities to allow large-scale operational assessment in real world deployments.

PHASE III DUAL USE APPLICATIONS: The commercial potential of a successful development would be large-scale in the Domestic Preparedness and First Responder Community (Fire, Police, Emergency Medical Services) due to its low cost and passive use.

REFERENCES:

1. Examples of published work in this field include the OSHA “USA Standard Acceptable Concentrations of Hydrogen Sulfide” which documents a hydrogen sulfide spot detector on which the optical density of a black spot on a paper filter changes (http://www.osha.gov/OshDoc/Interp_data/I19950928.html). Also OSHA published “Aromatic Isocyanate Surface Contamination Sampling and Evaluation Techniques”, documenting the use of color change pads as a visual indicator of isocyanate (http://www.osha.gov/SLTC/isocyanates/mrl_inte.html).

KEYWORDS: Colormetric, Toxic Industrial Compounds, Force Health Protection, Low Level, Chemical

N02-118 **TITLE:** Individual Bio Sensor / Sampler

TECHNOLOGY AREAS: Chemical/Bio Defense

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: Nuclear-Biological-Chemical

OBJECTIVE: Develop a small, lightweight, low-cost biological aerosol sampler with an integrated bio/non-bio or class based (bacteria, virus, toxin) detector to indicate to the wearer/operator the presence of suspect material. The sampler portion of the system will collect an air sample at a minimum rate of 15 L/min with an average collection efficiency of 50% over the 1 - 10 um particle size range. Sample format will be suitable for easy extraction into 1 ml of buffer solution. The system will be capably of running from batteries or AC/DC power sources. The system must meet sound level requirements to operate at less than 70 dB.

DESCRIPTION: Current DoD assets for biological aerosol collection and detection are very large and expensive systems and are few in number. Furthermore, they are unsuitable for wide scale civilian use as part of domestic preparedness efforts. By reducing the size, cost, and complexity of a biological aerosol collection/detection system, a much broader distribution can be employed on a routine basis. These systems would provide the soonest possible post-exposure indication of a biological aerosol exposure to facilitate diagnosis and treatment within the incubation period of most biological warfare agents. Bio/Non-Bio or class based detection will indicate where to sample and when to analyze samples. Furthermore, dual use of the technology for standard Industrial Hygiene practice would allow monitoring of HVAC systems for legionnaire's disease, molds, etc.

PHASE I: Show proof of concept to miniaturize a bio/non-bio or class based biological aerosol detector and integrate with an aerosol collector within size, weight constraints.

PHASE II: Construct prototype systems suitable for testing the performance of detection and collection capabilities. Conduct testing using biological warfare agent simulants and HVAC pollutants.

PHASE III: Transition to the Family of Weapons of Mass Destruction Response Systems (MC only), Joint Modular Chemical and Biological Detection System (SOCOM) and the Joint Chemical Biological Individual Sampler program (Pending). Commercial application to the Domestic Preparedness and Infrastructure Protection effects would be immediate.

PHASE III DUAL USE APPLICATIONS: The application will be sales to the domestic preparedness market (i.e. Department of Justice, State and local fire, police, EMS, hospitals) and the industrial hygiene market (i.e. sick building monitoring).

REFERENCES:
1. Thomas E. McKone, et al, Strategies to Protect the Health of Deployed U.S. Forces National Academy of Sciences Institute of Medicine, 2000,p. 99-105.

KEYWORDS: Biological, Aerosol, Detection, Sampling, Individual, Sensor

N02-119 **TITLE:** Non-Lethal Area Denial to Personnel

TECHNOLOGY AREAS: Weapons

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: Joint Non-Lethal Weapons Directorate

OBJECTIVE: To explore new non-lethal capabilities in the application of measured, selectable force for Area Denial to Personnel that will reduce risks in both noncombatant and combatant casualties, friend or foe and damage to collateral equipment and structures.

DESCRIPTION: The AD-P program desires a payload (can be chemical, liquid, electrical, material, etc) that can be used to deny area to personnel in urban/suburban regions (city streets, urban canyons, etc). The payload should be deployed from existing systems (or those within a year of first unit equipped (FUE)), from various ranges with areas of effectiveness covering 0-500 meters. The effects on personnel can vary from repel, delay, deny, disrupt, or incapacitate. Some examples of existing systems under consideration are: 81 mm mortar; 155 mm howitzer; CLADS/Volcano; Mark 19 grenade launcher; 2.75 inch rocket; UAVs with payload capability; non-lethal mines. Proposals must be innovative, include R&D initiatives and involve technical risk.

PHASE I: Develop innovative system concept for denying an area to Personnel without significant collateral damage or casualties.

PHASE II: Optimize Phase I design and demonstrate prototype system against a realistic target.

PHASE III: Optimize prototype system for technology solution(s) and demonstrate effectiveness of complete system. This demonstration should involve human and/or animal test subjects as appropriate, and as such the correct protocols need to be approved.

PHASE III DUAL USE APPLICATIONS: This system could be used by law enforcement agencies for riot, crowd control, hostage situations and area denial (i.e. bridges, tunnels, power plants and reservoirs).

REFERENCES:
1. Joint Non-Lethal Weapons Concept, Signed by LtGen M.R. Steele, Deputy Chief of Staff for Plans, Policy, and Operations, U.S. Marine Corps on 1/05/98, Available on World Wide Web at http://www.jnlwd.usmc.mil/

KEYWORDS: Personnel, Non-Lethal, Area Denial

N02-120 **TITLE:** Omni-Vision System for Day/Night Unmanned Ground Vehicle (UGV) Reconnaissance, Surveillance, and Target Acquisition (RSTA)/Mobility

TECHNOLOGY AREAS: Ground/Sea Vehicles, Sensors, Electronics, Battlespace

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: Unmanned Ground Vehicles/Systems Joint Project Office

OBJECTIVE: Enable small/medium sized UGVs to perform day and infra-red (IR) RSTA and driving functions without a large pan/tilt unit.

DESCRIPTION: Gimbaled vision systems have proven viable in both military and commercial applications due to their excellent performance, clear transmission, and payload controllability. This approach, however, requires physically pan/tilting a number of optical sensors, which results in a very significant size and weight payload package. Typical pan/tilt units used in small/medium sized UGVs today range from 50 pounds and up plus another 50 or more pounds for sensors and enclosure. Often this entire weight must be elevated for RSTA missions. The penalty on total system size/weight is unacceptable. Little or no work has been done to adapt new technology and improved vision systems for use on small robots. Small robots require a minimum number of lightweight moving parts yet the RSTA must provide 360 degrees and –45 to +90 degree vision.

PHASE I: Research current state of the art in omni-vision systems and develop a design for a small (1000 pound or less) UGV system. The design should include cost estimates for prototype development, production assessment, and technology risks. The omni-vision system must be self-contained with limited moving parts and capable of being integrated on UGV systems.

PHASE II: Develop a prototype omni-vision system for demonstration to the UGV/S JPO. The prototype module must provide 360 degree and –45 to + 90 degree view for both day video and infrared while minimizing movement of mass.

PHASE III: Omni-vision RSTA modules would be designed for integration into existing and future DOD robotic systems including Gladiator and Man-Portable Robotic Systems. Omni-vision systems can be applied to situations and events in which use of direct human action may cause catastrophic results.
PHASE III DUAL USE APPLICATIONS: The system would be applicable to any small commercial robotic system.

KEYWORDS: Small, Rugged, Robotic, Unmanned, Vision, RSTA

N02-121 **TITLE:** Personnel Neuromuscular Disruptor Incapacitation System

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace, Weapons

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: Non-Lethal Weapons and Urban Operations

OBJECTIVE: The Marine Corps needs a capability to incapacitate personnel as point or area targets with neuromuscular disruptors from long range (100 meters).

DESCRIPTION: This topic seeks an incapacitation system or system of systems that will provide a capability to incapacitate personnel with neuromuscular or neurological disruptors. Current technology for this is limited to Teaser type systems that deliver an electric shock at a peculiar pulse characteristic and power that disrupts or overpowers the transmission of signals from the brain to the muscles. We are looking for a non-chemical technology that can cause a person to be unable to control their muscles or even render them unconscious. It is required that the system works in the open in the 0-100 meter range or more if possible. The system must be non-lethal throughout the entire 0-100 meter range.

PHASE I: Demonstrate insofar as possible the scientific, technical, and commercial merit and feasibility of the idea submitted, by producing a system design, and analysis to establish expected performance. Implement the technology with a brass board model of the critical components that demonstrates the applicability and indicates the safety and effectiveness of the proposed system. Providing a report on the capabilities based on cost, schedule, technical performance and risk.

PHASE II: Build a prototype of the system proposed in Phase I. The prototype shall be produced to best commercial practices. Develop a commercial marketing plan for the system.

PHASE III: Further develop the system for both commercial and military applications. The resultant system shall be made commercially available by the close of Phase III.

PHASE III DUAL USE APPLICATIONS: Military and law enforcement organizations have a need to render unconscious or otherwise prevent or control action on the part of personnel from a 0-100 meter range.

REFERENCES:
1. Mission Need Statement for Clear Facilities

KEYWORDS: Incapacitation, Non-Lethal, Urban Operations, Neuromuscular Disruptor, and Directed Energy.

N02-122 TITLE: Range Variable Non-Lethal Munitions

TECHNOLOGY AREAS: Weapons

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: Non-Lethal Weapons and Urban Operations

OBJECTIVE: Range variable NL munitions that are NL over their entire engagement range, from muzzle to max range (100m). This could include fuses that sense target range and adjust themselves to be non-lethal based upon the sensed range to target.

DESCRIPTION: This topic seeks Range Variable Non-Lethal kinetic energy munitions that are Non-Lethal over their entire engagement range, from muzzle to max range (100m). The munitions could include new highly accurate fuses, and proximity sensors that sense target range or some other system that programs their time to function. The munitions function would then be to adjust their configuration to be non-lethal based upon the sensed range to target by increasing their surface area or some braking technology just before hitting the target.

The system must be very near to 100% reliable so that the target is never hit by a full velocity projectile that has not reconfigured its shape to be non-lethal.

PHASE I: Demonstrate insofar as possible the scientific, technical, and commercial merit and feasibility of the idea submitted, by producing a system design, and analysis to establish expected performance. Implement the technology with a brassboard model of the critical components that demonstrates the applicability and indicates the safety and effectiveness of the proposed system. Providing a report on the capabilities based on cost, schedule, technical performance and risk.

PHASE II: Build a prototype of the technology demonstrated in Phase I. The prototype shall be produced to best commercial practices. Develop a commercial marketing plan for the system.

PHASE III: Further develop the system for both commercial and military applications. The resultant system shall be made commercially available by the close of Phase III.

PHASE III DUAL USE APPLICATIONS: Military and law enforcement organizations have a need for range variable non-lethal kinetic energy munitions that are non-lethal over their entire engagement range, from muzzle to max range (100m). This could include systems that sense target range and adjust their characteristics (velocity, configuration, etc) to be non-lethal based upon the sensed range to target.

REFERENCES:
1. Mission Need Statement for Clear Facilities

KEYWORDS: Incapacitation, Non-Lethal, Urban Operations, Fuse, Range Sensors

NAVAL SEA SYSTEMS COMMAND (NAVSEA)

N02-123 **TITLE:** Integrated System Design and Maintenance Modeling Tools for CBM

TECHNOLOGY AREAS: Ground/Sea Vehicles

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT 1: PMS500 – DD(X)

OBJECTIVE: Develop new software technology and tools incorporating intelligent decision support and intelligent/dynamic maintenance procedures to enable the efficient use of emerging prognostic-based health management system technologies. The resulting solution will facilitate expanded, cost effective Condition Based Maintenance (CBM)/Prognostic Health Management (PHM) and effect a "prescription-based" health management concept. This advanced concept of a prescription-based health management system would provide ship and shore maintenance personnel with autonomously generated instructions/treatments to ensure that ship equipment will support immediate operational and mission requirements. The new technology will use or interface with planning/scheduling tools to optimize the application of prognostic information. Decision support functions within the solution will consider a number of factors including; safety, mission requirements, costs, and resources to trigger appropriate maintenance actions. Once a maintenance action has been triggered, the specific maintenance process and procedure will be optimized and dynamically served to the technician. The technology developed under this topic will generate efficient maintenance processes to incorporate automated prescriptions for executing maintenance actions identified by health management systems that incorporate low level automated diagnostic and prognostic capabilities. A prescription-based health management system (PBHMS) concept will be developed to integrate with the automated health diagnosis and prognosis components of existing machinery health management, control and monitoring systems. The objective is to ultimately reduce the overall operation and support (O&S) costs of shipboard systems and enable future transition of CBM and PHM information systems to automated mission contingency management systems (i.e.: systems that enable the selection of the right maintenance, at the right time, for the right mission).

DESCRIPTION: The ship system CBM and health management process is analogous to the medical health management processes. There are six fundamental elements in the process: Monitoring, Detecting, Diagnosing, Prognosis, Prescribing, and Treating/Executing. There are a variety of technical efforts directed at design and development of prognostic methods, this effort is directed at the efficient and intelligent use of prognostic results. A prescription-based health management system (PBHMS) for ship systems and equipment will provide treatment recommendations and act as an automated reasoner, capable of recommending intelligent decisions on operations and maintenance actions for all significant system Lowest Replaceable Units (LRUs), components and sensors. The PBHMS is desired for processing information from various health management information sources including; Trends, Experience, Diagnostic Monitors, Prognostic/Predictive Monitors and Observations. It should be able to recommend appropriate operations and maintenance actions according to best practices of the system, as well as schedules not only on parts that have already failed, but also those which are impending or still healthy, based on safety, cost, risk, convenience, operational, and mission considerations.

Different prescription architectures and algorithms need to be explored in the development of the PBHMS for this research topic. The technical approaches should be capable of linking system failure modes and particular maintenance tasks with operational and mission requirements through the PBHMS. Various data and information analysis technologies should be explored to weight actions prescribed by the PBHMS based on failure mode attributes, current safety and risk, costs, etc. should also be used to rank the operations and maintenance actions most needed. In the end, when the prescription-based health management system is called upon, an integrated system model could be activated and all possible paths between evidence sources, failure modes, and maintenance actions would be available for feed reasoning and decision support software analysis engines. The maintenance ranking will be determined based on the strength of the cumulative attributes of the components in this system model. Ultimately, the choice of the prescription that will be implemented for a PBHMS would be the simplest and most intuitive approach that still proves highly effective on the test cases demonstrated.

PHASE I: Develop and demonstrate a proof of concept for automating and optimizing the prescription element from prognostics information (i.e. part & remaining useful life) to facilitate Condition Based Maintenance. Develop preliminary design documents to support the Phase II development of a prototype prescription health management system. Preliminary design documents shall not only address planned hardware and software considerations but also open systems architectures that can support the progressive integration of specialized prescription algorithms. The specialized prescription algorithms would accept input from a variety of health management information sources and be capable of presenting intelligent decision options on required operations and maintenance actions. This proof of concept needs to be developed for a particular Naval combatant ship system or subsystem relevant to future destroyers and have direct application to a Navy CBM systems and/or Combat System electronics components.

PHASE II: Select critical PBHMS components, both software and hardware and assemble them into a limited PBHMS prototype. Build, test and verify the limited PHMS prototype for the particular Naval combatant ship system or subsystem addressed in Phase I. Integration with an existing Naval CBM system like the Integrated Condition Assessment System (ICAS) through Open Systems Architecture standard like OSA/CBM is required. Extension of this PBHMS concept to Joint Service applications like the JSF pHM concept should also be addressed. This integration shall fully enable a prescription technology which provides automatically generated work orders for the execution of maintenance actions for those applications selected for the limited PBHMS prototype. During Phase II, the preliminary system design documents and specifications developed in Phase I shall be matured to a level of detail sufficient to support the design, manufacture, test and evaluation of a first production model system under Phase III.

PHASE III: Design, manufacture, test and evaluate a first production model PHMS for the particular Naval combatant ship system/subsystem addressed in Phase II. Develop and demonstrate additional commercial and Naval applications for the PHMS.

PHASE III DUAL USE APPLICATIONS: This concept of PHMS will enable industry to efficiently utilize evolving prognostics capability to improve just-in-time parts management systems, increase the reliability and efficiency of ERP systems, and enable the automation of the entire CBM process from detection to execution.

REFERENCES:

1. "Prognostic Enhancements to Naval Condition-Based Maintenance Systems," M. J. Roemer, T. R. Galie, et. al, Improving Productivity Through Applications of Condition Monitoring, 55th Meeting of the Society for Machinery Failure Prevention Technology, April, 2001, Virginia Beach
2. A Case Study of the Application of Neural Nets to Diagnosis and Prognosis of Shipboard Machinery Performance and Failure Mechanisms", T. R. Galie, 12th Ship Control Systems Symposium, The Hague, Netherlands, October 1999
3. OPNAVINST 4700.7J, "Policies and Procedures for Maintenance of Ships

4. “Applying RCM Principles in the Selection of CBM-Enabling Technologies”, Kenneth S. Jacobs, presented at ASNE Conference, Norfolk, October 1999
5. “US Navy Lessons Learned in SMART Ships and Related Technology Initiatives”, NSWCCD Tech Report, T. R. Galie and M. Greenberg, June 2000

KEYWORDS: Condition Based Maintenance, Health Monitoring, Autonomous Assessment, Diagnostics, Prognostics, Open Systems Architecture

N02-124 **TITLE:** Power Harvesting for Shipboard Health Monitoring Sensors

TECHNOLOGY AREAS: Ground/Sea Vehicles, Sensors, Electronics

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT 1 – DD(X)

OBJECTIVE: Develop and commercialize modules for harvesting energy from interior shipboard environments to provide electrical power to Condition Based Maintenance sensor systems, including: sensing elements, integrated electronics, and integrated wireless communications elements.

DESCRIPTION: Several exploratory research studies have been conducted showing the feasibility of extracting power from environmental sources such as tides, wind, sunlight, vibration, shock, heat, and animal life to either replace or augment batteries as electrical power sources. The use and life-cycle-cost of integrating smart and/or wireless sensors in system health monitoring applications is severely limited by current battery life. A concept for harvesting energy from internal shipboard environments to provide low level electrical power has been demonstrated recently the Navy’s Reduced Ship’s crew by Virtual Presence (RSVP) advance technology project. However, the RSVP demonstration components are not adequately scaled in size and electrical energy capacity to support the small one cubic inch volume targeted for integrated condition health monitoring sensor systems that are emerging into commercial markets.

PHASE I: Develop and demonstrate a design concept for one or a family of electrical power harvesting modules. The module concept(s) shall be demonstrated to physically and electrically integrate with the current state-of-the-art wireless sensors designed for shipboard monitoring of machinery health condition. The concept shall demonstrate the conversion of environmentally produced power into electrical power sufficient to eliminate the tethered wires that provide external electrical power to the wireless sensor systems. Concepts for direct supply of power to sensor electronics as well as concepts for significantly extending the replacement life of small volume batteries will be addressed. A concept demonstration of the most promising electrical power harvesting design will be provided. Produce preliminary design documentation sufficient to design and demonstrate a prototype power harvesting system.

PHASE II: Design and demonstrate a prototype power harvesting system, based on the Phase I concept, in an integrated wireless sensor used for assessing condition of a shipboard system (i.e.: propulsion system, communications system, electrical power generating and distribution system, environmental and electronic cooling system, etc.) and a comparable commercial system. Develop design documents and drawings sufficient to support the design, manufacture, test and evaluation of a first production model power harvesting system.

PHASE III: Design, produce, test and evaluate the first production model of a fully integrated, complete power harvesting system for a full suite of machinery condition assessment wireless sensors and demonstrate the performance of the power harvesting system in a shipboard and commercial machinery CBM application. Complete the design documentation and drawings sufficient to support full scale manufacturing production of power harvesting systems/modules.

PHASE III DUAL USE APPLICATIONS: Electrical power harvesting for extending small volume battery life has commercial potential in the consumer appliance industry, security and surveillance industry, transportation industry, aerospace industry, and maritime industry.

REFERENCES:
1. RSVP ATD Final Technical Report, OPNAVINST 4700.7J, “Policies and Procedures for Maintenance of Ships
2. “Applying RCM Principles in the Selection of CBM-Enabling Technologies”, Kenneth S. Jacobs, presented at ASNE Conference, Norfolk, October 1999
3. “US Navy Lessons Learned in SMART Ships and Related Technology Initiatives”, NSWCCD Tech Report, T. R. Galie and M. Greenberg, June 2000
4. “Intelligent Sensor Nodes Enable a New Generation of Machinery Diagnostics and Prognostics,” F. M. Discenzo, K. A. Loparo, D. Chung, and A. Twarowski, New Frontiers in Integrated Diagnostics and Prognostics, 55th Meeting of the Society for Machinery Failure Prevention Technology, April, 2001, Virginia Beach

KEYWORDS: Sensors, Power Harvesting, Condition Based Maintenance, Wireless

N02-125 **TITLE:** Free Space Optics Near-ship Low Probability of Detection Communication Capability

TECHNOLOGY AREAS: Information Systems, Biomedical, Electronics

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT 1 – DD(X)

OBJECTIVE: Develop an innovative near-ship multiple-node infrared communication capability to establish wireless communications between operating units as small as an individual person operating within 1 kilometer (km) of a ship.

DESCRIPTION: Use of the radio frequency (RF) spectrum for military communications provides an opportunity for the detection and direction finding of military platforms by opposing forces. A communication system needs to be deployed to support operational activities on the deck of individual ships and between ships. The potential activities supported include but not restricted to the following: underway replenishment, aircraft launch and recovery, fuel and ordinance handling, VTUAV launch/recovery and small boat operations. An approach that would eliminate RF emissions would be the free space optics (FSO) work being commercially developed using the unregulated infrared portion of the electromagnetic spectrum. Current technologies are implemented for 850 nanometers (nm) and 1550 nm. Current operation of 850 nm technologies is more economical but 1550 nm technology may be safely operated at higher power levels without damage to the human eye.

Develop a communications system, which can form a near-ship (the deck of a ship to 1 km distance) wireless communications link between moving units (including individual personnel). The objective architecture should be extendable to support more than 10 remote personnel nodes. Any technologies, which eliminate RF emissions, should be considered. The approach must operate reliably in all kinds of weather. With low latency and a bit error rate (BER) of not less than 10-6, the objective system should accommodate a variable-speed data rate (1.544 Megabit/sec under optimum propagations conditions to a minimum of 64Kilobit/sec adverse conditions such as fog) with low latency (less than 1 second delay). The system, at a minimum, must be suitable for ship-to-person communications with a projected capability for ship to aircraft. In the objective system, lower procurement and maintenance costs are a consideration. The approach, while minimizing or controlling propagation anomalies to minimize detection must have no health hazard to humans and should be environmentally friendly.

PHASE I: The contractor shall demonstrate the feasibility of the proposed design, including developing the architecture, for an innovative communications system which is all weather, with low latency and a bit error rate (BER) of not less than 10-6, the system must accommodate a variable-speed data rate (1.544 Megabit/sec or greater under optimum propagations conditions to a minimum of 64 Kilobit/sec adverse propagation conditions) with low latency between moving operating units. Document concept and possible design.

PHASE II: Develop and document the prototype communications system identified in PHASE I. Build a prototype system using at least one stationary node, one moving (30 Kilometers/Hour or less) vehicle node, and four moving human nodes. The prototype system shall be used in a proof of concept demonstration to validate the network capabilities as well as its ability to meet the various performance, safety and environmental requirements.

PHASE III: Integrate the prototype communications system with a Navy communications or data link system in order to see how effective data can be passed between the nodes. Demonstrate system by performing field tests. Develop and produce a deployable system.

PHASE III DUAL USE APPLICATIONS: The wireless communications industry is the predominant target market in the commercial sector. Non-RF networking will help commercial and military applications that are being crowded out of currently used RF spectrum in urban environments This technology approach greatly increases both the distance and data rate over existing infrared applications.

REFERENCES:

1. "Fiber Optics without Fiber", Willebrand, H.A. and Ghuman, B.S., IEEE Spectrum, August 2001, pp. 41-45
2. D.J.T. Heatley, D.R. Wisely, I. Neild, P. Cochrane, Optical wireless: the story so far, IEEE Communications Magazine , Volume: 36 Issue: 12 , Dec. 1998, Page(s): 72 -74, 79-82
3. "Considerations on the Design of Transceivers for Wireless Optical LANs", Aguiar, R. L., Tavares, A., Cura, J. L., Vaconcelos, E., Alves, L. N., Valadas, R., Santos, D. M., IEE Coloquia, June 1999, pp. 2/1-2/17
4. "Wireless Infrared Communications", Kahn, J. M., and Barry, J. B., Proceedings of the IEEE, Volume 85, No. 2, February 1997, pp. 265-298.

KEYWORDS: Fiber Optic, Free-Space Optics, Non-Radio Frequency Communications

N02-126 **TITLE**: Free Space Optics Ship to Ship Network Communication Capability

TECHNOLOGY AREAS: Information Systems, Materials/Processes, Electronics, Battlespace

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT 1 – DD(X)

OBJECTIVE: Develop an innovative medium range infrared communication capability to form a wireless network between operating units.

DESCRIPTION: Commercial use of the radio frequency (RF) spectrum severely limits use of current and project military communications systems. Existing military communications systems must contend with a variety of interfering signals while insuring that military systems do not interfere with commercial systems. An approach that would minimize or eliminate RF emissions would be the free space optics (FSO) work being commercially developed using the unregulated infrared portion of the electromagnetic spectrum. Current technologies are implemented for 850 nanometers (nm) and 1550 nm. Current operation of 850 nm technologies is more economical but 1550 nm technology may be safely operated at higher power levels without damage to the human eye. Develop a communications system, which can form a medium range (nominally 50 km) wireless network between moving operating units. Any technologies, which eliminate RF emissions, should be considered. The approach must operate reliably in all kinds of weather. With low latency and bit error rate (BER) of no less than 10-6, the objective system should accommodate a variable-speed data rate (100Megabit/sec at close range to a minimum of 64Kilobit/sec at maximum range) with low latency (less than 500 millisecond delay). The system as a minimum must be suitable for ship-to-ship Line-of-Sight (LOS) communications with a projected capability for ship to aircraft and ashore. The approach, while minimizing or controlling propagation anomalies must have no health hazard to humans and should be environmentally friendly.

PHASE I: The contractor shall demonstrate the feasibility of the proposed design, including developing the architecture, for an innovative communications system which is all weather, with low latency and BER of no less than 10-6, the system must accommodate a variable-speed data rate (100Megabit/sec at close range to a minimum of 64Kilobit/sec at maximum range) with low latency between moving operating units. Document concept and possible design.

PHASE II: Develop and document the prototype communications system identified in PHASE I. Build a prototype system using at least one stationary node and two moving nodes. The prototype system shall be used in a proof of concept demonstration to validate the network capabilities as well as its ability to meet the various performance, safety and environmental requirements.

PHASE III: Integrate the prototype communications system with a Navy communications or datalink system in order to see how effective data can be passed between the nodes. Demonstrate system by doing field tests. Develop and produce a field able system.

PHASE III DUAL USE APPLICATIONS: The wireless communications industry is the predominant target market in the commercial sector. Non-RF networking will help commercial and military applications that are being crowded out of currently used RF spectrum in urban environments. This technology approach greatly increases both the distance and data rate over existing infrared applications.

REFERENCES:

1. “Fiber Optics without Fiber”, Willebrand, H.A. and Ghuman, B.S., IEEE Spectrum, August 2001, pp. 41-45
2. D.J.T. Heatley, D.R. Wisely, I. Neild, P. Cochrane, Optical wireless: the story so far, IEEE Communications Magazine , Volume: 36 Issue: 12 , Dec. 1998, Page(s): 72 -74, 79-82
3. “Considerations on the Design of Transceivers for Wireless Optical LANs”, Aguiar, R. L., Tavares, A., Cura, J. L., Vaconcelos, E., Alves, L. N., Valadas, R., Santos, D. M., IEE Coloquia, June 1999, pp. 2/1-2/17
4. “Wireless Infrared Communications”, Kahn, J. M., and Barry, J. B., Proceedings of the IEEE, Volume 85, No. 2, February 1997, pp. 265-298.

KEYWORDS: Fiber Optic, Free-Space Optics, Non-Radio Frequency Communications

N02-127 **TITLE:** Ship Dynamics/Ship Air Wake Interface

TECHNOLOGY AREAS: Air Platform

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT 1 – DD(X)

OBJECTIVE: Execution of this SBIR will provide for the linking of autonomous and manned rotary wing aircraft flight simulation models with ship dynamic behavior and air wake characterization models. The goal is to enable design optimization and performance assessment of organic aircraft launch and recovery effectiveness using time accurate data to support flight simulation.

DESCRIPTION: Safe and effective launch and recovery of aircraft depends upon the controllability of the aircraft in the wind and wave environment. Important air wake parameters that effect aircraft controllability include turbulence intensity, scale (time and space) and predictability. The wave environment results in a dynamic ship motions response. The magnitude and predictability of flight deck motion will effect the safety of launch as the aircraft leave the deck and recovery as the aircraft touches down. In current air wake models, the ship is assumed to be steady and moving at a constant speed and direction through a uniform flow field. Ship motions will result in ship dynamic responses that change the character of the ship's air wake. Both the modeling of the interface between ship dynamics and the characterization of the air wake is essential to accurately simulation of aircraft launch and recovery evolutions. A simulation model of scalable fidelity will provide the designer with the capability to influence the ship design, assess the aggregate launch and recovery performance and provide training for warfighters on board both aviation and ship systems.

PHASE I: Develop the concept for integrating autonomous and manned rotary and fixed wing aircraft flight simulation models with ship dynamic behavior and air wake characterization models. Define the interface between air wake and a ship dynamics model that captures the physics important to providing an accurate simulation of aircraft launch and recovery evolutions. Recommend improvements to the simulation models that are needed to support an effective interface. Develop a human interface model that simulates the critical elements of the integrated system to be developed in Phase II.

PHASE II: Develop software interface module based on the findings developed in Phase I that provides for the linking of autonomous and manned rotary wing aircraft flight simulation models with ship dynamic and air wake characterization models. Improvements to software, needed to support rotary wing aircraft launch and recovery simulations, will be performed during this second phase. Results of computations performed by the modified software will be compared to sub-scale and full scale (where available) physical test/trial data to define the uncertainty associated with each element of performance prediction.

PHASE III: Transition the technology (hardware/training/procedures/etc.) to the U.S. Navy infrastructure. This transition will probably involve partnering/licensing or selling the technology to the Navy or Navy prime contractor for QA of new construction and also lifecycle support.

PHASE III DUAL USE APPLICATIONS: The commercial world will benefit directly from this software module (autonomous and manned fixed and rotary wing static version) which will permit the improvement of commercial aircraft take-off and landing safety and improving effectiveness.

KEYWORDS: Air wake, Ship, Dynamics, Ship Motions, Aircraft

N02-128 **TITLE:** Highly Effective EM Shielding Technique for Ship Composite Structures

TECHNOLOGY AREAS: Materials/Processes

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT 1 – DD(X)

OBJECTIVE: Develop low Radar Cross Section (RCS) composite structures and components that are corrosion resistant and can be easily integrated into a ship such that they provide excellent (>60 dB) electromagnetic (EM) shielding effectiveness in the 100 kHz to 20 GHz frequency range.

DESCRIPTION: Composite structures and components provide an inherent weight advantage and, typically, are more corrosion resistant than their steel counterparts. As a result, composite structures and components are being considered for use in shipboard applications. However, composite structures do not provide the same inherent EM shielding effectiveness, without being designed into the structure, provided by steel or aluminum. While EM shielding effectiveness of 60 dB and greater in frequency ranges of 1 GHz and higher have been achieved with composite material, EM shielding effectiveness levels in the 100 kHz to 1 GHz ranges have been much less. Furthermore, treatments/ techniques used to achieve structure and component-shielding effectiveness has been difficult to integrate into other composite and steel structures such that the total ship's shielding effectiveness integrity is achieved and maintained. A low-maintenance corrosion resistant technique is necessary to provide for an effective transfer of RF energy to other structures.

There have been treatments applied to composite structures that provided 60 dB and greater EM shielding effectiveness; however, they frequently introduce corrosion control problems. In addition, other treatments, that may provide excellent lower frequency shielding effectiveness, may add significant weight to the composite structures or components and offset the weight advantage of composite material. A technique for achieving excellent EM shielding effectives in the 100 kHz to 20 GHz range while minimizing weight increase, achieving corrosion control, and providing for low radar cross section goals needs to be developed.

The techniques proposed should be applicable to composite structures and components in Navy ships. Also, the techniques should be general enough to handle different types of composite structures and components being used or being proposed for Navy ships.

PHASE I: Demonstrate the feasibility of proposed design techniques for providing >60 dB EM shielding effectiveness in the 100 kHz to 20 GHz frequency ranges using low-signature, corrosion resistant composite material. These designs or techniques should address predicted EM shielding effectiveness levels, how the shielding levels will be achieved, techniques for integrating composite structures and components into other composite and steel structures such that total system shielding effectiveness integrity is maintained.

PHASE II: Develop and test the design techniques that provide >60 dB EM shielding effectiveness. This should include a demonstration of the shielding effectiveness in the 100 kHz to 20 GHz range, RCS, resistance to corrosion when subjected to a severe marine environment, and ability to assist in achieving a low radar cross section.

PHASE III: Transition the technology (hardware/training/procedures/etc.) to the U.S. Navy infrastructure. This transition will probably involve partnering/licensing or selling the technology to the Navy or Navy prime contractor for QA of new construction and also lifecycle support.

PHASE III DUAL USE APPLICATIONS: The commercial world will benefit directly from these techniques in addressing potential Electromagnetic Interference problems on commercial airframes.

REFERENCES:
1. MIL-STD-1310G of 28 Jun 1996, Standard Practice for Shipboard Bonding, Grounding, and Other Technique for Electromagnetic Compatibility and Safety
2. IEEE 299 of 9 DEC 1997, Standard Method for measuring the effectiveness of EM Shielded enclosures.
3. MIL-STD-1377 of 20 Aug 1971, Effectiveness of cable, connector and weapons enclosure shielding and filters
4. MIL-STD-188-125-1, of 17 July 1998, HEMP Protection for ground based C4I facilities performing critical time urgent missions, Part 1, fixed facilities

KEYWORDS: Composite, Corrosion, Bonding, RCS, EMI, Electromagnetic

N02-129 **TITLE:** Shipboard Applications of Near Frictionless Carbon (NFC

TECHNOLOGY AREAS: Materials/Processes

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT 1 – DD(X)

OBJECTIVE: Explore the maintenance savings and operating efficiency improvements of shipboard applications (marine environment) of Near Frictionless Carbon coatings including, but not limited to, pumps, fans, windlasses, winches, steering gear, reduction gears, door and hatch hinges, elevators, and gun mounts.

DESCRIPTION: Naval ships contain many systems that have rotating, sliding or otherwise wearing surfaces. Many of these systems require significant maintenance for lubrication and wear related adjustments. NFC materials have not readily been applied or tested in shipboard marine applications. Any technologies that could potentially reduce the lubrication, wear related adjustments and extend the operating life of the systems could have a large impact on the total ownership cost of the fleet.

PHASE I: Determine the performance characteristics of NFC in a marine environment, including salt air, sea spray and submergence in seawater. Identify potential applications of NFC and determine the feasibility from a cost and maintenance reduction impact that would result from using these NFC materials. If performance is appropriate for a marine environment these NFC materials could be tested in Phase II.

PHASE II: Conduct tests of actual NFC coatings used in the potential applications identified in Phase I. A variety of potential applications should be tested, including continuously rotating machinery and cyclical operating equipment such as doors or hatches.

PHASE III: Work with Navy In-Service Engineering Agents (ISEA), to create a series of equipment specifications and standard drawings, if applicable, to facilitate fleet introduction of NFC based equipment.

PHASE III DUAL USE APPLICATIONS: Applicable to similar systems in commercial marine environments including shipping, oil and gas exploration.

REFERENCES:
1. http://www.itd.anl.gov/techtour/nfc.html

KEYWORDS: Materials, Coatings, Frictionless, Carbon

N02-130 **TITLE:** Barrel Coating and Liners for Extended Barrel Life

TECHNOLOGY AREAS: Materials/Processes

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT II: Gun Weapon Systems Technology, Naval Surface Fire Support (PMS 529)

OBJECTIVE: Develop and demonstrate innovative materials, processes, and techniques to substantially reduce thermomechanical erosion and material loss in shipboard gun barrels. The specific requirement is to increase the barrel life of the 5″/62 Mk 45 Mod 4 gun firing the EX 171 Extended Range Guided Munition (ERGM) and its EX 167 propellant from 1500 rounds to 3000 rounds.

DESCRIPTION: Gun barrel erosion limits the life and performance capabilities of shipboard guns and adversely affects the operating costs and required force levels of Naval Surface Combatants. It is believed that the barrel life firing ERGM with EX 167 propelling charges will be an unsatisfactory 1500 rounds. Future NSFS requirements for longer ranges and higher levels of lethality dictate the introduction of new projectile designs and the use of higher energy and temperature propellants, that naturally produce higher chamber pressures and temperatures. Such operating conditions accelerate the thermomechanical erosion of the barrel. Erosion constraints may preclude the implementation of new propellants and projectiles.

PHASE I: Develop an approach to reducing the barrel erosion of the 5″/62 Mk 45 Mod 4 gun. The approach may be a coating, liner, or other protective treatment of the barrel, but may not require changes to the propellant or projectile, or large-scale changes to the geometry or material of the barrel and chamber. The 5”/62 barrel is rifled and the gun fires both fin stabilized projectiles with slip obturators and spin-stabilized projectiles with traditional rotating bands. The approach used must allow both capabilities. Permanent treatments are preferred over treatments that require reapplication or retreatment. Good bonding of the treatment material to the gun is essential. In Phase I the contractor should develop the approach to be used and predict the improvement it will produce through analysis, modeling, and bench-scale tests. The Phase I analysis should also develop methodology to extrapolate the results of accelerated wear tests. This methodology will be used to translate the results of a ten-shot accelerated wear test at elevated temperature and pressure to an estimated barrel life firing standard rounds.

PHASE II: Develop, fabricate, and test the approach chosen in Phase I. Demonstrate the performance of the approach in an accelerated wear test at a Navy prototype gun. The accelerated wear test will be conducted using a prototype high pressure and temperature gun that has a removable forcing cone. As the final product of the Phase II effort, the contractor will deliver a forcing cone treated with the wear-reducing process developed. The Government will use the prototype gun to fire a ten round test series at 90,000 psi with a high-energy, high temperature propellant such as JA2 (3300 K) or EX99 (3010 K). (EX99 is the propellant in the EX167 propelling charge.)

PHASE III: Based on the results of the accelerated wear test, approaches that demonstrate the capability to at least double the service life of the barrel will be considered for Phase III. This phase entails treatment of an Mk 45 Mod 4 gun barrel and life testing under actual firing conditions, and transition of successful treatments to the 5″/62 Mk 45 Mod 4 gun.

PHASE III DUAL USE APPLICATIONS: Reducing erosion in internal combustion and diesel engines will yield longer life engines with reduced life cycle costs and less frequent down times for maintenance. Lowering erosion in the hot sections of gas turbines, for aircraft propulsion and power generation will prevent efficiency loss in these machines, keeping down the cost per unit of generated thrust or power.

REFERENCES:
1. Montgomery, J and Ellis, R, "Large Caliber Gun Materials Systems Design", 10th US Army Gun Dynamics Symposium, 23 - 26 April 01.
2. Paul J. Conroy et al, Extended-Range 5-in Navy Gun: Theoretical Thermal and Erosion Investigations, US Army Research Lab ARL, Report # ARL-TR-2473.
3. Jackie Y. Ying et al, Processing and Deposition of Nanocrystalline Oxide Composites for Thermal Barrier Coatings, Technical Report on ONR Grant No. NOOO14-95-1-0626 for the Period of October 1,2000-December 3 1,2000, Report # ADA387191.
4. Samuel Sopok and Mark Fleszar, Ablative Erosion Model for the M256/M829E3 Gun System, US Army Armament Research, Development and Engineering Center ARDEC,, Report # ADA392147.
5. Gjigialante P. Cote et al, Laser Pulse Heating Simulation of Firing Damage on Coated Gun Bore Surfaces, US Army Armament Research, Development and Engineering Center ARDEC, Report # ARCCB-TR-01005.
6. Paul J. Conroy et al, Gun Tube Coatings In Distress, US Army Research Lab ARL, Report # ARL-TR-2393.
7. Jeffrey S. Swab et al, Evaluation of Monolithic Ceramics and Ceramic Thermal Barrier Coatings for Diesel Engine Applications, US Army Research Laboratory ARL, Report # ARL-TR-2436.
8. Paul J. Conroy et al, Initial Studies of Gun Tube Erosion Macroscopic Surface Kinetics, US Army Lab ARL, Report # ARL-TR-2546

KEYWORDS: Shipboard Gun Barrels, Interior Ballistics, Thermomechanical Erosion, Ablative Shields, Ceramics, Coatings, Liners, Erosion Barriers

N02-131 **TITLE:** In-Bore Dynamic Instrumentation for Navy Gun Barrels

TECHNOLOGY AREAS: Materials/Processes

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT II - Gun Weapon Systems Technology Program, Naval Surface Fire Support

OBJECTIVE: Improve the instrumentation available to measure the real time conditions inside the gun barrel during the ballistic cycle. The specific capability desired is to gather multi-point measurements at the bore surface of temperature, pressure, gas velocity, and possibly indications of molecular species. Of most importance, is the ability to measure the true shape of the thermal transient pulse at the bore surface. This information will be used to validate the improved interior ballistics and erosion models and to predict the impact of new propellants and gun designs on barrel erosion and performance. Applications of this instrumentation to an operational gun condition measurement system is also possible in the long term, to enhance the ability of the ship to monitor the gun for dangerously high temperatures and detect undesirable changes in gun performance.

DESCRIPTION: This topic seeks the development of key components of an integrated real-time instrumentation system to continuously monitor the ballistic conditions inside gun barrels and chambers. Key parameters to be measured are pressure, temperature, and gas flow velocities in multiple locations inside the barrel. The ability to characterize molecular species resulting from combustion is also desired. A system that can be used without excessive modification to the gun would be most useful. Current sensors require pressure ports to be drilled into the chamber and barrel, and temperature sensors wells are drilled to about ¼ inch from the bore surface. Current temperature sensors have the ability to measure the residual temperature after the thermal pulse is induced at firing. It is desired that the developed sensor has the ability to sense at a rate fast enough to capture the shape of the temperature vs. time transient during gun fire (5-30 msec). This system has to be flexible and rugged enough to accommodate a wide spectrum of propellant/projectile combinations involving high energy and temperature propellants. Performance at pressures up to 120,000 psi and temperatures up to 3300 K is required.

PHASE I: Develop a design concept and sensor suite. Demonstrate capability through bench-scale and critical experiments to help justify its feasibility.

PHASE II: Develop a prototype and demonstrate, through actual bench-scale and full-scale tests, its capability to monitor ballistic conditions and thermomechanical erosion inside the barrel as also validate the capability to accurately predict cook off in hot guns.

PHASE III: Based on the results of phase II demonstration tests, the instrumentation system will be developed into a gun research and development tool, with further development possible into an operational monitoring (material condition assessment) tool for shipboard guns.

PHASE III DUAL USE APPLICATIONS: This system will have wide use in monitoring high-temperature, high-pressure industrial processes such as ore smelting, steam generation, and chemical plants.

REFERENCES:

1. W. Horst et al, Quantitative Assessment of Pressure Waves in Guns, US Army Research Lab ARL, Report # ARBRL-TR-02319 007.
2. Stuart Dunn and Samuel Sopok et al, "Unified Computer Model for Predicting Thermochemical Erosion in Gun Barrels", Software and Engineering Associates, Inc. and US Army Benet Labs, 31st AIAA/ASME/SAE/ASEE Joint Propulsion Conference and Exhibit, July 10-12, 1995/ San Diego, CA, AIAA 95-2440.
3. John D. Sullivan, Gelled Water Bag Cook Off Tests, US Army Research Lab ARL, Report # ARL-MR-507
4. James A Schmitt et al, Two Phase Viscous Flow Modeling of Interior Ballistics, Algorithm, and Numerical Predictions for an Idealized Lagrange Gun, US Army Research Lab ARL, Report # ARBRL-TR-02465.
5. Martin S. Miller, A Chemically Specific Burning Rate Predictor Model for Energetic Materials, US Army Research Lab ARL, Report # ARL-TR-2390.

KEYWORDS: Sensors, Guns, Prediction, Instrumentation, Erosion, Interior Ballistics, Hot Gun, Cook Off

N02-132 **TITLE:** Autonomous Prescription of Maintenance Requirements

TECHNOLOGY AREAS: Ground/Sea Vehicles

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT 1 – DD(X)

OBJECTIVE: Develop a comprehensive, model based software architecture (or "framework") for the design and integration of sensor modules, health assessment modules, diagnostic modules, prognostics modules, and decision support modules into shipboard CBM enabled systems. The software architecture must support emerging Open System Architecture (OSA) information processing standards for Condition Based Maintenance (CBM) and be able to integrate with existing central shipboard condition assessment systems such as ICAS (Integrated Condition Assessment System), as well as be extensible to Joint Service applications like the Joint Strike Fighter pHM systems. Integrate this framework into a set of commercial design tools that will enable ship system designers and life cycle management personnel to identify and select the most cost effective measurement, diagnostic, and prognostic technologies for the purpose of incorporating these technologies in the systems during manufacturing design and re-design for the purpose of integrating autonomous condition assessment functions into equipment installed aboard Navy Surface Ship Combatants.

DESCRIPTION: The equipment health management community is replete with a variety of monitoring, diagnostic and prognostic engineering methods, algorithms, and maintenance processes. In addition, there are a vast array of equipment types, models and various operating environments for shipboard equipment. In order to intelligently build, deploy, and maintain effective autonomous condition assessment capabilities in shipboard systems, a model based software framework is needed. This software framework must capture system unique (i.e.: propulsion system)mechanical designs, controls designs, failure modes, failure effects, failure criticality, reliability, and diagnostics/prognostics methods in unique graphical models of the individual systems. The framework must be able to assess the effectiveness and the fault coverage of potential measurement, diagnostic, and prognostic technologies and processes. The framework must also support development and simulation testing of alternative mixes of technologies and processes to enable the system designer and maintenance manager to select the most cost effective mix delivering a ship system with an integrated self-assessment capability. The architecture should support open libraries of measurement, diagnostic and prognostic algorithms and processes that can be applied against the system model, assessed, and easily exported to a run-time CBM system operating under Open Systems Architecture (OSA) CBM concepts and compatible with the existing shipboard CBM information management infrastructure (i.e. ICAS).

PHASE I: Demonstrate a concept for a model based software framework for development and implementation of ship system monitoring, diagnostic, and prognostic solutions. The concept must use a system design and/or modeling software package and demonstrate the capability to pull various measurement, diagnostic, and prognostic approaches together, and "overlay" them on a partial model of a shipboard system (i.e.: propulsion system, communications system, electrical power generating and distribution system, environmental and electronic cooling system, etc.). The concept must demonstrate that the software framework enables the system designer/maintenance manager to assess the overall effectiveness of the approaches to provide an integrated assessment of the system's health. The concept must also be demonstrated to support OSA CBM information processing standards and concepts.

PHASE II: Select a complete shipboard system and expand the Phase I concept into the design a prototype software package including system design tools, system operational models and simulations, and libraries of monitoring/diagnostic/prognostic algorithms and processes. Demonstrate the performance metrics of the framework and the cost effectiveness of various mixes of monitoring, diagnostic, and prognostic solutions through the application of the framework the selected shipboard system. Export the optimum mix of approaches as a simulation of an autonomous ship system condition assessment capability to a run-time CBM function (and to interactive maintenance and guided troubleshooting software modules). The software framework should also demonstrate user-friendly modeling (knowledge capture), ease of model update/maintenance, ability to easily add new prognostic methods via open libraries, and seamless implementation of run-time diagnostics/prognostics in a CBM system. Prepare a set of adhoc, draft standards for commercial and military standards organizations to incorporate the autonomous condition assessment model based framework in system design tools, system functional specifications, and system maintenance processes.

PHASE III: Produce a full set of industry-standard, system design, software tools for integrating hardware and software condition assessment modules in commercial and military systems. Incorporate the Phase II draft standards in commercial and military standards documents.

PHASE III DUAL USE APPLICATIONS: The tools and standards developed by under this topic could be used by any systems manufacturer or system design and maintenance engineering agent (commercial or military) to incorporate autonomous condition assessment capabilities into their systems and maintenance processes. There is potential benefit to the power generation industry, the chemical processing industry, transportation industry, maritime industry, mining industry, aerospace industry, the electronics industry, and the building industry.

REFERENCES:

1. “Reasoning and Modeling Systems in Diagnosis and Prognosis”, Krishna R. Pattipati and T. R Galie, presented at SPIE’s 15th International Symposium on Aerosense, April 2001, Orlando
2. “Prognostic Enhancements to Naval Condition-Based Maintenance Systems,” M. J. Roemer, T. R. Galie, et. al, Improving Productivity Through Applications of Condition Monitoring, 55th Meeting of the Society for Machinery Failure Prevention Technology, April, 2001, Virginia Beach
3. OPNAVINST 4700.7J, “Policies and Procedures for Maintenance of Ships
4. “Applying RCM Principles in the Selection of CBM-Enabling Technologies”, Kenneth S. Jacobs, presented at ASNE Conference, Norfolk, October 1999
5. “US Navy Lessons Learned in SMART Ships and Related Technology Initiatives”, NSWCCD Tech Report, T. R. Galie and M. Greenberg, June 2000

KEYWORDS: Condition Based Monitoring, Condition Based Maintenance, Health Monitoring, Prescription, Workload Analysis, Enterprise Resource Planning

N02-133 **TITLE:** Sensorless Control of Linear Motors

TECHNOLOGY AREAS: Sensors, Electronics

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT ID: PMS 378 – CVN(X) Next Generation Nuclear Aircraft Carrier

OBJECTIVE: Develop a sensorless control scheme, including hardware and algorithms that can effectively and accurately control a long linear motor.

DESCRIPTION: The Navy is interested in pursuing sensorless control schemes for linear motors that can rival traditional control techniques in performance. Present motor control techniques are very capable, in particular Field Oriented Vector (FOV) control. However, this technique relies on precise knowledge of the various states of the machine (phase currents, position, speed, etc.). In order to obtain these states, the necessary parameters are physically measured and fed back to the control system. These sensors reduce reliability and increase parts count as well as cost. For rotary machines, these measurements are typically straightforward and within the capability of existing sensors, but as stated previously they add cost and parts, while reducing reliability. For a linear motor, position and speed sensing is even more complex and difficult, relying on unique methods that add cost while reducing the reliability of the overall system. Such is the case with the Electromagnetic Aircraft Launch System (EMALS) which is a linear motor system intended to replace the current steam catapults on naval aircraft carriers. The EMALS will accelerate aircraft to flying speed in the short space available on the carrier flight deck. In this system, the ability to accurately and reliably measure position and speed is critical to proper, efficient performance. It presently requires a complex and possibly maintenance-intensive sensing system. An advanced control scheme that accurately and reliably estimates the states of the machine without feedback from sensors would prove invaluable to EMALS, increasing reliability while reducing parts count, cost, and maintenance. This control scheme must be able to operate effectively during the transient, high acceleration conditions of the EMALS operation and maintain less than 2% error from the commanded velocity. It must be able to operate with block switching over the length of the linear motor. A control scheme that exhibits these characteristics could significantly reduce the maintenance and increase the reliability of linear motors that will be used in the future Navy, in particular the EMALS.

PHASE I: Conduct a study assessing the feasibility of advanced sensorless control techniques, such as back-emf, high frequency induction, and advanced state estimators. Provide a determination and risk assessment of these technologies and their ability to meet the stated requirements. Prove, through analysis, model and/or lab demonstrations that the concepts could meet the stated requirements.

PHASE II: Develop the hardware and software necessary to demonstrate the sensorless control system on a linear motor system.

PHASE III: Produce a militarized version of the sensorless control system that could be tested at the EMALS test site at NAVAIR, Lakehurst. A successful system could be integrated into EMALS aboard future carriers.

PHASE III DUAL USE APPLICATIONS: This technology has direct and immediate benefits for all types of commercial motors, both rotary and linear.   Existing motors and generators rely heavily on sensors to maintain proper operation. These sensors are typically the most failure prone components in the system and require maintenance and calibration. The ability to eliminate them from the system will have tremendous advantages for maintainability and reliability.

REFERENCES:
1. "Electromagnetic Aircraft Launch System (EMALS)", IEEE Transactions on Magnetics, January 1995, Volume 31, Number 1.
2. "The Benefits of Launching Aircraft Electromagnetically", Naval Engineers Journal, May 2000, Vol. 112, Number 3.

KEYWORDS: Sensorless Control, Linear Motors

N02-134 **TITLE:** High Density Electric Energy Storage

TECHNOLOGY AREAS: Electronics

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT ID: PMS 378 - CVN(X) Next Generation Nuclear Aircraft Carrier

OBJECTIVE: Research enabling technologies for developing a solid-state electric energy storage device that stores energy at very high energy densities.

DESCRIPTION: The Navy is very interested in pursuing solid-state electric energy storage technologies that could achieve an energy density that approaches 10 kJ/kg and a power density approaching 8 kW/kg. Such technologies could be transitioned to several FNC programs and the Electromagnetic Aircraft Launch System (EMALS) program, which seeks to replace current steam catapults aboard aircraft carriers with an electromagnetic means of launching aircraft. To be viable for this application, the technology would need to deliver energy of approximately 180 MJ with a peak power approaching 200 MW in approximately 2 seconds. In addition, this energy storage system should be able to maintain its energy store for 5 minutes in a standby mode and operate in the 2 to 5 kV range. A system that exhibits very high energy density capability could significantly reduce the ship's weight and center of gravity, making the ship more stable and buying back service life allowance. Because of reliability and maintainability issues, solid-state technologies are preferred.

PHASE I: Conduct an assessment of the feasibility of developing a storage system described above. Prove, through analysis, models and/or lab demonstration, that the concept(s) could meet the stated requirements. The assessment should include a high-level assessment of cost and producibility.

PHASE II: Produce a small-scale prototype and demonstrate in the lab.

PHASE III: Produce a full-scale system for land-based testing at the EMALS test site at the Naval Air Warfare Center Aircraft Division Lakehurst. A successful system could be integrated into EMALS aboard future carriers.

PHASE III DUAL USE APPLICATIONS: An improved electric storage system could benefit a wide range of applications, including MAGLEV trains, power plants, generation of shock waves, high power lasers and pulsed high magnetic fields.

REFERENCES:
1. "Electromagnetic Aircraft Launch System (EMALS)", IEEE Transactions on Magnetics, January 1995, Volume 31, Number 1.
2. "The Benefits of Launching Aircraft Electromagnetically", Naval Engineers Journal, May 2000, Vol. 112, Number 3.

KEYWORDS: Solid State Electric Energy Storage, Pulse Power

N02-135 **TITLE**: Aircraft Carrier Environmental Maintenance Enclosure

TECHNOLOGY AREAS: Air Platform, Battlespace

OBJECTIVE: The goal of this SBIR is to develop an environmental enclosure that is modular in design, portable, lightweight, easy to erect, capable of withstanding heavy winds and will enhance the removal and application of non-skid systems materials in Aircraft Carriers.

DESCRIPTION: One of the major issues with Aircraft Carriers today is premature flight and hangar deck non-skid systems failures and high maintenance costs. Findings of recent on-site visits to CV63, CV64, CVN72 and CVN74 indicate premature non-skid failures on Aircraft Carrier flight decks. New technology aircraft have increased platform weights, which increases the average engagement speed during a recovery of the aircraft contributing to the degradation of the coefficient friction factor (slip resistance) on the flight deck. Problems exist in that there is a lack of control of the ambient environment and substrate conditions during the removal and application process of the non-skid systems. Failures occur in the application process of the primer and non-skid systems due to global weather conditions. Currently, no known materials or systems exist to protect a non-skid application surface under the necessary environmental requirements, while being lightweight, modular, portable, quick to erect and robust enough to withstand heavy winds usually encountered on an Aircraft Carrier flight deck, while tolerating the Navy's fire, smoke and toxicity requirements.

PHASE I: Conduct a study assessing the feasibility of developing a composite structure including material selection and format . Explore and chose design options for building a portable modular enclosure that is light weight, quick to erect, robust to withstand heavy winds, that meets the Navy's fire, smoke and toxicity requirements. Demonstrate through structural and wind load analysis, that an environmental enclosure is feasible for Aircraft Carrier use. The environmental enclosure should be capable of generating temperature, humidity and ventilation requirements necessary for the application of non-skid.

PHASE II: Develop, fabricate and erect a prototype composite modular environmental enclosure, which will meet the temperature, humidity and ventilation controls necessary for the application of non-skid. Test and evaluate the performance and design at a facility modeled after an aircraft carrier flight deck.

PHASE III: Transition the environmental enclosure for use in the Aircraft Carrier fleet, air capable ships and shore facilities requiring the technology.

PHASE III DUAL USE APPLICATIONS: The proposed environmental enclosure can be used in conjunction with non-skid coating systems, which are used on commercial ships, overland transportation roadways, recreational areas such as swimming pool decks, tennis courts, theme parks, etc. Additionally, the proposed enclosure can be used to control the application of non-skid materials on marine and offshore drilling platforms with aircraft capabilities; airport landing strips and runways.

REFERENCES:
1. NSTM Chapter 634, Deck Coverings; Naval Message 290525Z, 1 January 2001

KEYWORDS: Structure, Portable, Lightweight, Modular, Environmental Control, Flight Deck, Non-Skid

N02-136 **TITLE**: Compact, High Power Midwave Infrared Lasers

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT II; PMS 473 – Advanced Integrated Electronic Warfare System (AIEWS) AN/SLY2

OBJECTIVE: Develop technology in 3.5 – 5 micron, pulsed or continuous wave, medium/high power lasers, and nonlinear optics.

DESCRIPTION: High power midwave infrared (MIR) lasers generating 10 – 20 Watts average power output have been demonstrated. The sources used a solid-state laser to pump optical parametric oscillator(s) for frequency conversion into the MIR region. While these lasers have met performance requirements for many applications, system size/complexity, packaging, reliability, maintainability, cost and other issues for military and commercial applications/platforms issues have to be resolved. Innovative proposals are sought to explore the potential of new solid state pump lasers and improved or new nonlinear optical materials for more efficient frequency conversion to generate pulsed or cw output powers of 5 – 10 Watts in each of the 3.5 – 4.1 micron and 4.4 – 5 micron atmospheric transmission windows. Multiple laser lines in each spectral band and beam quality that is less than ten millimeter-milliradian are required. For a pulsed source, a pulse repetition frequency of 20 kHz is required. An efficient, high modulation depth (>104) modulator is also required to allow laser output modulation of up to 5 kHz at a 50% duty cycle. The goal is to develop technologies for a laser that will be smaller than one cubic foot, weigh less than 50 lbs, and have reduced cooling requirements.

PHASE I: Explore concepts from an analytical and/or experimental perspective to determine the feasibility of a compact, high power MIR laser meeting the output power, wavelength and beam quality requirements. The Phase I effort shall address the design and performance of a system to be fabricated in Phase II as well as power scaling issues in achieving 20 Watts output power.

PHASE II: Design, fabricate, test and deliver a compact laboratory brassboard laser that meets the aforementioned requirements to the Navy.

PHASE III: Design, fabricate, test and deliver the 50-lb high power MIR laser to the Navy.

PHASE III DUAL USE APPLICATIONS: Potential applications include the use of such a laser source for nuclear proliferation monitoring, process control, medical surgical system, and pollution sensing of hydrocarbon molecules.

REFERENCES:
1. Eric Cheung, et al, “High Power Conversion to Mid-IR Using KTP and ZGP OPOs”, OSA Trends in Optics and Photonics Vol. 26, Advanced Solid-State Lasers, M. Fejer, H. Injeyan, and U. Keller, eds. (OSA, Washington, DC 1999), pp. 514-517.
2. P. A. Budni, et al, “High Power 1.9 Micron Pumped Solid-State Holmium Lasers”, paper CFA1, CLEO 2000.

KEYWORDS: Infrared, Laser, Compact, High Power, Frequency Conversion, Photonics

N02-137 **TITLE**: Integrated Information Architecture for Crisis Management and Response

TECHNOLOGY AREAS: Information Systems

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: PEO TSC: PMS 400D

OBJECTIVE: Leverage existing mature sensor and Information Technology products to rapidly field an integrated capability to disseminate crisis management data (such as perimeter intrusion, chemical/biological attack, flooding or fire). The system should report tactical and material readiness situation summaries. Crisis management doctrine, and enterprise-wide response management across all involved domains, (e.g. operations, security, damage control, medical, rapid response teams, local, force, theater, CINC and national reporting authorities) shall be considered and addressed in the design of the system(s). The integrated family of systems will support shipboard and land based crisis management requirements. Commercial technologies shall be leveraged to develop a modular, flexible, scalable and portable system architecture which facilitates affordable introduction of new functionality to meet emerging threats. Strategies for interoperability with existing C2 and C4ISR capabilities will be developed and demonstrated. The system(s) produced will be capable of installation on surface combatants and auxiliaries during pier side availability and when required to support land based infrastructure requirements.

DESCRIPTION: Effective crisis management of contemporary asymmetric warfare threats requires development of an integrated information architecture facilitating interface to and interpretation of feeds from a myriad of sensor types, and timely dissemination of derived coordinated crisis response strategies to a diverse set of shipboard, first responder, local and national activities. Legacy stove piped system architectures are unable to meet these requirements. An integrated information architecture system will provide the common system infrastructure to support C/B/R/N/E, Anti Terrorist Barrier Protection and DC crisis management and response activities for ships and naval facilities. Such a system will accept feeds from both local and external cueing sensors in support of C/B/R/N/E requirements. Furthermore, the system will accept and disseminate data feeds from below surface detection and above surface perimeter detection sensors deployed pier side or at anchorage. The DC sensor feeds shall include as a minimum fire, smoke, temperature, combustible/toxic gas, flooding detection, monitoring and remote threshold setting capability. The use of WEB-based mainstream commercial products will be crucial to affordably fielding a system with the requisite flexibility, scalability and coordinated reach across a divergent set of responder domains. Effective use of wireless communications links such as tactical radio, 802.11 Ethernet and Ultra Wide Band as well as open and secure Internet communications formats will be necessary to effectively link large areas of netted sensor data feeds, data processing and first responder and command and control sites. The use of consolidated displays has been determined to be a major contributor to reduced manning. Therefore, capabilities to interface with common operating environment (COE) based C4ISR sensor feeds and displays and shipboard C2 display architectures are required. Capability to link voice and video data for all modes must be considered and addressed, as it may one day be required. Another technology for reducing manning is embedded training. Concepts for implementation of embedded training will be essential to maximizing system effectiveness across the user community.

PHASE I: Prepare a feasibility concept for implementation of the required C/B/R/N/E, Anti-Terrorist Barrier Protection, and Damage Control crisis management and response capabilities using existing commercial products to facilitate near term fielding as well as identification of emerging technologies capable of enhancing performance in future SBIR phases and product builds.

PHASE II: Integrate and demonstrate a prototype system for ship and land based crisis management and response. Present an initial set of expected actions in each of the functional areas using a common presentation format tailored to requirements for each functional area. Provide a robust and highly challenged shore-based demonstration of the ability to interconnect the system with multiple sensors types and interactive displays. Plan for interfacing the developed system with C4ISR data feeds and displays at the Joint Battle Experiments Lab during follow-on Phase III effort. Phase II shall adequately document the product baseline demonstrated in this SBIR to support production and installation efforts.

PHASE III: Develop a full set of expected actions in each of the functional areas. Incorporate maturing technology for demonstration/evaluation of worth as functional enhancements. Execute demonstration of interfacing the developed IIA with C4ISR data feeds and displays at the Joint Battle Experiments Lab as well as techniques for interfacing with Shipboard C2 displays demonstrating collaborative crisis management and response connectivity between unit, force, CINC and first responder and supporting subject matter expert participants. Phase 3 shall document the product baseline demonstrated during the JBEL demonstration to support production enhancements, installation changes and operational doctrine.

PHASE III DUAL USE APPLICATIONS: Products developed through this SBIR will have direct and timely applicability to crisis management and response needs for commercial transportation, critical infrastructure (power plant, port authorities) and local and federal government agencies (police, fire departments, medical, FEMA, FBI, Secret Service, etc.).

REFERENCES:
1. CNO 091; 2000 Red Book Command Capability Issues; August 2000.

KEYWORDS: Chemical, Biological, Defense, Protection, Information, Architecture

N02-138 **TITLE:** Automatic, Non-Intrusive Chemical, Biological, and Radiological (CBR) Threat Detection

TECHNOLOGY AREAS: Information Systems

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: PMS 400D, PEO TSC

OBJECTIVE: Develop innovative enabling technologies/approaches/systems/processes to enable automatic, non-intrusive detection of Chemical, Biological, and/or Radiological (CBR) threats with low false alarm rates at reduced costs. The need for CBR threat detection has become increasingly critical to national and international security. Current detection techniques rely on systems that are intrusive, expensive, time-consuming, and/or can be unreliable. A “penetration-capable” CBR detection system will enable reduced shipboard workload for functions (such as examining packages delivered to Navy ships) and will increase the ship’s protection against asymmetrical threats.

DESCRIPTION: With increasing pressure on shipboard workload and emerging schemes for reduced/optimized shipboard manning, it becomes increasingly important to eliminate sources of workload not directly related to power projection. With increased reliance on commercial sources for Navy supplies, there is a possibility of increased risk to Navy ships from enlarged access via ship infrastructure. This infrastructure, especially with respect to supply from foreign ports, presents opportunities for attack from Chemical, Biological, and/or Radiological threats. Required are systems and approaches that enable non-intrusive detection of Chemical, Biological, and/or Radiological agents. Systems exist and are in development for the remote/point detection of threats such as the M22 Automatic Chemical Detection Alarm (ACADA) and Ship ACADA, AN/KAS-1A Chemical Warfare Directional Detector, Interim Biological Agent Detector (IBAD), M-21 Remote Sensing Chemical Agent Alarm, and Joint Chemical Agent Detector (JCAD) (to name a few). Required is a system that can automatically and rapidly scan and assess the internal contents of personnel, packages, or other items delivered to ships to reduce the risks from possible asymmetrical threats, and also reduce the workload associated with CBR threat detection. One possible approach might be the use of ultra wideband (UWB) terahertz (THz) millimeter wave technology to make use of the absorption and reflection spectral characteristics predicted from many large biological molecules such as DNA as well as chemical molecules commonly found in explosives to radiation within the submillimeter wave and THz region of the electromagnetic spectrum. Large organic molecules have distinctive rotational and vibrational energy levels in the THz range and THz energy penetrates many materials that are opaque to microwave and optical energy. However, this represents only one of many possible approaches to meeting this need.

PHASE I: Develop concept for an affordable, innovative shipboard system for automatic, non-invasive detection of Chemical, Biological, and/or Radiological threats. Develop a characterization database of common and objective CBR threats/agents and document the subset of CBR threats targeted. Document approach, projected acquisition and lifecycle costs and shipboard workload impacts, and projected capabilities, full-scale characteristics, and other metrics in support of movement to Phase II.

PHASE II: Analyze and demonstrate feasibility of approach developed in Phase I in laboratory and simulated shipboard environments. Document approach, projected full-scale system ship impacts (size, weight, acquisition and lifecycle costs, projected workload impacts, etc.) and projected capabilities and components. Demonstrate under multiple scenarios simulating operational conditions to evaluate capability including detection limits, false alarm rates, security impacts, and electromagnetic and other interferences/compatibility.

PHASE III: Develop transition plans and demonstrate the commercial and shipboard use of approach. Demonstrate under multiple shipboard scenarios full-scale capabilities, evaluate detection levels, false alarm rates, security, and electromagnetic and other interferences/compatibility.

PHASE III DUAL USE APPLICATIONS: The automatic, non-intrusive detection of Chemical, Biological, and/or Radiological threats is of extreme commercial interest given the recent Anthrax terrorist attacks delivered through the United States mail service infrastructure. Such a developed system could operate much like the metal detectors used by airports and could be utilized by the mail service, by airlines, by commercial shipping and cruise lines, as well as by large conference sites and buildings for passive, low-cost, non-intrusive detection of threats. Other potential military and commercial applications could include: chemical/biological & concealed weapons detection through clothing, building materials, etc.; imaging of surface contamination on structures; mapping plumes of chemical/biological materials in the environment (wide-area remote sensing); and medical scanning, automated process control, and food safety.

REFERENCES:

1. OPNAV Instruction 3400.10F, “Chemical, Biological and Radiological (CBR) Defense Requirements Supporting Operational Fleet Readiness,” 22 May 1998.
2. “Joint Doctrine for Operations in Nuclear, Biological, and Chemical (NBC) Environments,” Joint Chiefs of Staff Document, 11 July 2000, Joint Publication 3-11.
3. "Commercial Applications in Aircraft Carriers", Naval Sea Systems Command, PMS 312, Arlington, VA, March, 1999, prepared by MSCL Incorporated under Contract # N00024-95-C-4180: TIs 7J201, 8J008, 8J020, and 8J108.

KEYWORDS: Automatic, Non-Intrusive, Chemical, Biological, Radiological, Threat Detection

N02-139 **TITLE:** High Energy Solid State Laser (SSL) for Ship Self-Defense

TECHNOLOGY AREAS: Weapons

OBJECTIVE: Design, develop, and demonstrate components in support of a Solid State Laser System that can be packaged for naval platforms.

DESCRIPTION: Chemical lasers produce power levels in excess of a megawatt, however the wavelengths that they operate at are not suitable for maritime propagation. SSL’s provide the opportunity to adapt and optimize lethality effects in the maritime environment. While the current state of the art for Solid State Lasers produce insufficient power to be considered a naval weapon, serious efforts to scale up the average power of solid-state laser systems have been under way for over 30 years. Kilowatt class laser systems have been demonstrated by a number of groups, but the systems developed all had relatively poor beam quality. Great effort has been dedicated to improving beam quality through better thermal management and wavefront compensation. Solid State Lasers have considerable advantages for the maritime environment. These advantages include operating wavelengths more suited for the maritime environment, potential for scaling to high powers, pulsed waveforms that may offer lethality advantages over CW lasers, and a compact total system size that can be packaged for the Navy. The DoD High energy Laser Master Plan (HELRP) recommends that the DoD stimulate the High-Energy Laser supplier base with a few focused investments. Specifically, under Solid State Lasers, the top three priority investments are; 1) to develop reliable low-cost diodes for pumping lasers, 2) to investigate and develop improved methods for thermal management on high-energy solid-state-lasers, and 3) to develop and demonstrate techniques for beam combining of laser modules for high-energy applications. Specific laser requirements (as reported in the DoD HELRP) for this effort include efforts leading to: (1)Develop and demonstrate coherently phased fiber arrays; (2) Development of optical beam control techniques to allow high power Solid State Lasers to achieve good beam quality; (3) Development of thermal management techniques to allow continuous operation of solid state lasers at high power; (4) Development of more efficient solid state lasing mediums; (5) Scale-up Heat Capacity Laser (HCL) to 100's kw; (6) Develop long life reliable low cost diodes.

PHASE I: Investigate enabling component technologies and designs that are capable of enabling specific laser requirements listed above. Demonstrate component design feasibility via modeling and simple sub-scale or oversized experiments.

PHASE II: Utilize the findings established in Phase I to develop designs of functional components. Fabricate and conduct component demonstration. Conduct High Power SSL integration requirements study to develop specific component design characteristics.

PHASE III: Implement the integration of the enabling technologies into a Solid State Laser weapon demonstration test site to be determined in the future.

PHASE III DUAL USE APPLICATIONS: Many applications in materials processing require the use of high power laser beams for surface treatments. Development of a high power solid-state laser source will allow large-scale treatment of various materials by industry users. The treatments aid in the prevention of surface erosions, cracks, and other effects common to large surface area industrial materials.

REFERENCES:
1. DoD Laser Master Plan Volume II, August 2, 2000. ODUSD (S&T)/WS LMP Vol-II, 22 September 2000

KEYWORDS: Laser, Phased, Array, Fibers, Diodes, Thermal

N02-140 **TITLE**: Design and Build a Revolutionary Phased Array Radar System

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: PMS 426

OBJECTIVE: Design and build a revolutionary phased array radar system that will include new and innovative technologies and architectures that will address the following: (1) Weight Reduction; (2) Cost Reduction; (3) Stealth Capability; (4) Digital Signal Processing beam forming techniques; (5) Reconfigurability; (6) Significant flexibility in power aperture. Research and Development efforts selected under this topic shall demonstrate and involve a degree of technical risk where the technical feasibility of the proposed work has not yet been fully established.

DESCRIPTION: The Navy is interested in providing risk reduction alternatives for ongoing radar suite development to address threats that range from anti-ship missiles to ballistic missiles. In addition, current Naval Surface combatants have installed numerous Radar and Communication systems, whose antennas cover the entire electromagnetic spectrum, that create a virtual "antenna farm" on the decks and superstructures of these platforms. The associated antennas tend to interfere with each other and increase the overall RCS of the platform. In conjunction with sensor systems, these systems provide communications, situation awareness, threat indications and early warnings. In addition, they provide target detection, identification, classification, tracking and kill assessment for defense against ballistic and air breathing missiles. New and innovative approaches and designs are required to reduce the size, weight, cost and RCS of phased array radar systems and integrate them into future hull forms. All this needs to be done while meeting the radar system needs of the missions. To meet these requirements, these systems should be dynamically reconfigurable, stealthy, operate at reduced power levels while still providing warnings and detection with high probabilities at long range. New revolutionary architecture designs for the digital radar antenna need to be developed in such areas as: T/R modules, phase shifters, array elements, waveguides, all of which will have reduced life cycle support costs. Examples of some technology specific areas are: non-traditional configurations, embedded antennas, flat parabolic surfaces, non-metallic arrays, electromagnetic shielding for protection against electronic countermeasures and reduced aperture numbers while maintaining bandwidth integrity. Entirely new and high-risk approaches are also sought.

PHASE I: Design an architecture for a phased array radar capable of meeting the broad requirements outlined in this topic for future shipboard radar system consideration.

PHASE II: Develop applicable and feasible radar prototype demonstrations and/or proof-of-concept devices for the architectural design approach chosen and demonstrate a degree of commercial viability.

PHASE III: Develop pre-production and production phased array radar antenna systems and components for integration into Navy surface combatants.

PHASE III DUAL USE APPLICATIONS: These technologies would be applicable to wireless communications, commercial radars, RF tagging, mine detection and law enforcement.

REFERENCES:

1. M. Skolnik, “Radar Handbook”, McGraw Hill (1990)
2. D. R. Wehner,”High Resolution Radar”, Artech House (1987)
3. Richard Johnson and Henry Jasik, “Antenna Engineering Handbook”, McGraw Hill (1984)

KEYWORDS: Reconfigurable, Stealth, Broadband, Non-Metalic, Phased Array, Conformal

NAVAL AIR SYSTEMS COMMAND (NAVAIR)

N02-141 **TITLE**: Advanced Antenna Evaluation and Design Software with Radomes and Frequency Selective Surfaces

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT II: PMA 290 – Maritime Surveillance Aircraft (MSA) Leadership Program

OBJECTIVE: Develop and optimize a suite of codes to be used for designing antennas recessed in airframe surfaces that may incorporate radomes and frequency selective surfaces (FSS) with complex materials.

DESCRIPTION: Current state of the art does not allow for concurrent analysis of antennas in the presence of radome structures or coupling of such antennas with other nearby airframe devices. Of particular interest is the effect of the radome structures and coupling with other devices on the substructure. The emphasis is on geometrical and material adaptability, as well as on reducing design time. Computational speed and the development of a practical toolset are of primary concern. The toolset should incorporate constrained optimization routines that will automatically drive the process to a desirable design. Trade-off (Pareto) optimization is desirable. An array geometry generator, good pre- and post-processing capability, a geographical user interface (GUI), and a good users manual are a must.

PHASE I: Develop and demonstrate innovative computational algorithms for optimal performance. Test and validate the algorithms on typical antennas/arrays. Test the candidates on a variety of arrays. Down select and further test the final algorithms.

PHASE II: Develop an array/antenna geometry generator and post-processing capability. Design and develop a GUI that reflects the needs of antenna designers. Consider integration of array design toolsets to evaluate coupling on vehicles. Thoroughly test the GUI, preferably by antenna designers. Incorporate the designers’ feedback in the GUI's design.

PHASE III: Interface the toolbox with sophisticated commercial geometry generators, commercial optimization, and commercial post-processing packages.

PHASE III DUAL USE APPLICATIONS: As a result of the universal need for wireless communication and information collection, there is an increasing need for new and complex antenna designs in both the commercial and government sectors. The proposed product would be useful to any electronics firm, the communications industry, automotive industry, or computer industry.

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2. Munk, B. A., Frequency Selective Surfaces, New York: Wiley, 2000.
3. Wu, T. K., ed., Frequency Selective Surface and Grid Arrays, New York: Wiley, 1995.

KEYWORDS: Antennas, Antenna Arrays, Radomes, Electromagnetic Modeling, Optimization, Coupling

N02-142 **TITLE:** Low-Cost Laser Diodes for Navy Applications

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: PMA 272 – Advanced Tactical Aircraft Protection Program

OBJECTIVE: Develop and fabricate low-cost, efficient laser diodes for pumping solid-state lasers used in missile, unmanned aerial vehicle (UAV), and aircraft applications.

DESCRIPTION: The development of solid-state lasers, which serve as sources for laser radar systems, laser designators, and laser countermeasure systems, is emerging. One of the subsystems required for all laser systems is a means to pump the laser material. The pump of choice for future systems is the laser diode. An innovative approach to lower the cost of laser diode manufacturing while increasing overall efficiency is sought. The laser diodes must have an output wavelength appropriate to pump the several laser materials that are under development for the above applications. These materials include Nd:YAG, Nd:YVO4, Nd:YLF, and Yb:SFAP. Emphasis should be placed on overall efficiency of the laser diode. It is anticipated that the laser diode will operate in a continuous wave mode and have all appropriate cooling capability. The laser diodes should be capable of being fabricated into diode bars that can produce outputs of optical power of greater than 50 watts at the wavelengths required. An electrical-to-optical efficiency of greater than 45 percent will be a goal. Operation in a military environment will be essential for future applications; therefore, the laser diode must survive the shock, vibration, and temperature environments of a deployed device. The current cost of a 50-watt diode bar is $1,500 to $3,000, depending on the wavelength output and quantity purchased. Innovative design goals are required for the total cost of a 50-watt bar to cost $150 to $200 for the 1,000th unit with a pathway to lower cost for larger production runs.

PHASE I: Develop a conceptual design for efficient, low-cost laser diodes that meet Navy requirements, see reference. Include methodology and prototype performance that will demonstrate the proposed concept at the required power and wavelength.

PHASE II: Develop detailed designs for the Phase I efficient, low-cost laser diodes, and fabricate a limited number of diodes suitable for proof-of-concept testing and packaged in appropriate array designs. Conduct preliminary testing in a laboratory and in government-owned laser resonators. Testing in government-owned laser resonators will be provided at no cost to the SBIR contract.

PHASE III: Scale up for mass production of the advanced laser diodes. These efficient, low-cost laser diodes, upon meeting Navy requirements, will be transitioned into various laser designator programs and missile laser radar program.

PHASE III DUAL USE APPLICATIONS: Potential commercial use is in components for laser systems used in large-area displays, medical lasers, and semiconductor/lithography systems as well as the communication industry.

REFERENCES:
1. "Laser Diode Requirements for Navy Applications". This document will be provided to potential contractors upon request.

KEYWORDS: Laser Radar, Laser Diodes, Unmanned Aerial Vehicle, Missile, Neodymium, Crystals

N02-143 **TITLE:** Techniques and Models to Relate Useful Life Remaining Predictions to Detectable Fault Conditions in Mechanical Systems

TECHNOLOGY AREAS: Air Platform

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT I: Joint Strike Fighter

OBJECTIVE: Develop innovative statistical tools, models and techniques that would enhance and complement other research and development efforts attempting to define fault to failure progression models and provide accurate useful life remaining predictions for aircraft mechanical systems.

DESCRIPTION: In order to fully enable the predictive part of any prognostics and health management (PHM) concept there must be some capability to: relate detected incipient fault conditions to accurate useful life remaining predictions for any point in time; model the fault to failure progression; and account for manufacturing, build and usage differences in all mechanical components across the fleet. Technologies are now available to detect incipient failure conditions in many mechanical system component elements. There are other research and development efforts that are attempting to model the incipient fault to failure progression. The next step is to develop additional models to statistically account for manufacturing processes, build tolerances and fleet operating usage differences. This may be accomplished through merging of analytical models, statistical techniques, and actual failure experience data. This effort will develop, demonstrate, and apply these advanced models in support of the predictive part of PHM.

PHASE I: Define the techniques and processes needed to relate useful life remaining predictions to detectable fault conditions in mechanical systems. Develop a strategy for integrating the required detection and modeling components. Demonstrate the feasibility to develop the advanced models, statistical techniques, and other programs required.

PHASE II: Develop and demonstrate a prototype for these advanced models, techniques, and programs for aircraft mechanical subsystems and their components. Assess the application boundaries, accuracy, and limitations for these modeling techniques.

PHASE III: Develop, validate, and deliver a complete set of application modeling programs and techniques to be used on several aircraft systems. Integrate these capabilities with a comprehensive PHM system. Apply these modeling programs to a new aircraft development program like the Joint Strike Fighter (JSF).

PHASE III DUAL USE APPLICATIONS: These advanced models would be applicable to any mechanical machine application that was applying diagnostics, prognostics, and health management capabilities. This is particularly true of any rotating machines used in aviation, power plants, etc. Any results (understanding) gained from applying these failure progression rate models to particular systems would provide a significant crossover benefit to other similar applications, commercial or military.

REFERENCES:

1. SAE E-32 Committee Documents
2. ISO TC/SG5 Draft Standards
3. IEEE Aerospace Conference Proceedings for 2001 and 2002 Track 11 PHM

KEYWORDS: Diagnostics, Prognostics, Modeling, Failure Prediction, Forecasting, Condition Maintenance

N02-144 **TITLE:** Techniques and Prognostic Models to Relate "Useful Life Remaining" and "Performance Life Remaining" Predictions to Detectable Fault Conditions in Flight Control Actuators

TECHNOLOGY AREAS: Air Platform

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT II: PMA 265 - F/A-18 Program

OBJECTIVE: Develop and demonstrate incipient fault-to-failure progression models, innovative advanced prognostic models, statistical techniques, and other programs that can be used to relate accurate "useful life remaining" predictions to various types and degrees of fault and failure conditions within flight control actuators. These could be hydraulic, hydro-electrical, or electrical actuators.

DESCRIPTION: In order to fully enable the predictive part of any prognostics and health management (PHM) concept, there has to be some capability to relate detected incipient fault conditions to accurate useful life remaining predictions for any point in time. The key to accomplishing this is to understand incipient fault-to-failure progression characteristics for the flight control actuator components and having realistic and verifiable prognostic models. It is recognized that failure mechanisms for actuator components and understanding their fault to failure progression characteristics may be unique to this application and different from other types of aircraft components. Therefore, the resulting techniques and prognostic models will be unique to flight control actuation. This may be accomplished through the merging of an understanding of the physics of failure, analytical models, physical models, statistical techniques, and actual failure progression data as applied to aircraft actuator components. Some level of real-time sensor and/or measurable state awareness will be required input to these prognostic models and techniques.

PHASE I: Define the techniques and processes needed to relate "useful life remaining" predictions to detectable fault conditions in aircraft flight control actuators. Report on a strategy to develop the advanced models, statistical techniques, and other programs required. Develop an initial list of required inputs to the models, and outline a method of extracting them from the aircraft. Develop feasibility models that can be run on a standard PC platform and optimized to utilize a minimum of computing resources. Establish feasibility of proposed techniques , tools and advanced prognostic model solution. Define potential user interfaces.

PHASE II: Develop and demonstrate a prototype model for these advanced models, techniques, and programs for several aircraft applications of flight control actuators. Assess the application boundaries, accuracy, and limitations for these modeling techniques. Develop, validate, and deliver a complete set of application modeling programs and techniques to be used on legacy and future planned flight control actuator applications. Integrate these capabilities with a comprehensive PHM system.

PHASE III: Finalize these models with a major aircraft or engine manufacturer. Apply these modeling programs on a new aircraft development program like the Joint Strike Fighter (JSF) or Unmanned Combat Air Vehicle – Navy (UCAV-N), or as a retrofit onto legacy aircraft such as the F-14 and F/A-18 C/D.

PHASE III DUAL USE APPLICATIONS: These advanced models would be applicable to any actuator application across industry and that will be applying diagnostics, prognostics, and health management capabilities. Any results (understanding) gained from applying these failure progression rate models to actual actuators will provide a significant crossover benefit to similar applications, commercial or military.

REFERENCES:

1. SAE E-32 Committee Documents
2. ISO TC/SG5 Draft Standards
3. IEEE Aerospace Conference Proceedings for 2001 and 2002 Track 11 PHM

KEYWORDS: Diagnostics, Modeling, Useful Life Remaining Predictions, Prognostics and Health Management, Failure Prediction, Maintenance

N02-145 **TITLE:** Weapon System Operator Multi-Media Tactical Operation Aids

TECHNOLOGY AREAS: Air Platform

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT IC: PMA 231 - E-2/C-2 Leadership Council

OBJECTIVE: Develop innovative multi-media interface technologies to support tactical automated Command, Control and Communications (C3) as operational aids for interface and cueing operator actions in high interest and critical tactical situations.

DESCRIPTION: Weapon System Operators (WSOs) must respond to potentially hazardous situations in tactical noisy, mobile, ship and airborne environments. Innovative technologies are evolving to support the implementation of a multi-media "smart" interface as an operational aid in these environments. A WSO to tactical automated C3 system multi-media interface is sought to significantly improve the operator performance in high task load scenarios. This can be accomplished by developing the combined use of natural language speech commands, audio response, hands-free point/click and other advanced technology human interface cueing technologies, as an effective and efficient multi-media interface. The combined technology multi-media advanced human cueing interface with tactical weapon systems have the potential to significantly reduce operator workload while increasing the WSO's ability to react and proact to potentially hazardous situations. The multi-media design concept should be compatible and interoperable with tactical platforms and should not require the rewriting of tactical platform software.

PHASE I: Investigate the feasibility and develop a conceptual architecture for WSO automated weapon system interaction using hands-free point/click, natural language speech and other advanced cueing technologies for a combined and natural multi-media interface. Feasibility analysis should include: 1) Evaluation of tactical functions that can conceptually benefit from the individual advanced technology multi-media components and how they may be simultaneously employed; 2) Conceptualization of how multi-media operational aids should be implemented and employed for real-time situation reaction and proaction to support WSO tasks; 3) Evaluation of cueing technologies and methods, and how they can be efficiently combined and under what circumstances they should be initiated; 4) Research the most efficient software design concept that has minimal impact on tactical platform software.

PHASE II: Develop and demonstrate an operational prototype of the advanced cueing technologies multi-media interface design, to be tested in a demounted tactical platform in a laboratory environment. Document the enhanced WSO effectiveness, situational awareness and reduced task workload using a simulated tactical scenario.

PHASE III: Produce a tactically suitable multi-media interface product, then, install and operationally demonstrate it in the E-2C tactical platform. Document and quantify the improved WSO real-time interaction and situational awareness in a ground and airborne WSO test. Compare the benefits of the multi-media interface, using flight test results, with the traditional manual and the individual cueing technologies when implemented alone and in combination.

PHASE III DUAL USE APPLICATIONS: Numerous applications in air traffic control, unmanned vehicle command, industrial production monitoring, power plant control and distribution, entertainment, anti-terrorist screening, law enforcement and e-commerce vending.

KEYWORDS: Voice Command, Cueing, Tactical Decision Aids, Hands-Free Pointing, Multi-Media, Weapon System Operator

N02-146 **TITLE:** Digital Wireless/Copper Data Bus Combination for Intercommunication System Applications

TECHNOLOGY AREAS: Air Platform

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT II: PMA 231 E-2/C-2 Leadership Council

OBJECTIVE: Develop digital wireless bus architecture investigating the feasibility, unique requirements, and testing necessary to upgrade existing hard-wired intercommunications systems into a digital wireless bus architecture.

DESCRIPTION: The E-2C is a communication-intensive airborne early warning element supporting tactical and theatre commanders. Portions of the communication suite are secure. From time to time, the desirability of using a wireless inter-communication system (ICS) has been discussed to facilitate operator use, increase capacity, enhance mission effectiveness, improve reliability and maintainability, and facilitate replacement of the existing obsolete ICS. This system must interface with the joint tactical radio system architecture.

PHASE I: Research and analyze the E-2C ICS technology requirements and identify those that could best be addressed with a wireless system. Analyze the feasibility of combining wireless ICS technology with digital data bus based ICS technology. Address the E-2C hard wired ICS issues that could be resolved with wireless technology. Address the flexibility of use, recommended architectures, and user interface enhancements.

PHASE II: Develop and provide a working prototype of the digital wireless bus architecture. Perform limited laboratory and aircraft ground testing of the prototype. Document major issues and propose workable resolutions that lead to a flight worthy prototype. Provide preliminary drawings, a final report, and production cost estimates of the proposed final design.

PHASE III: Develop, manufacture, integrate, and flight-test an airworthy prototype. Procure, install, and support production into the E-2C fleet aircraft.

PHASE III DUAL USE APPLICATIONS: Numerous applications in air traffic control, airport ground control, and other military aircraft with multiple crew stations.

KEYWORDS: Intercommunications, Wireless Protocols, Data Bus Protocols, Digital; Obsolescent Aircraft, Tactical Radio System

N02-147 **TITLE:** Modeling and Simulation of Hot Gas Ingestion and Steam Ingestion Characteristics for Aircraft Propulsion System Performance and Operability Assessment

TECHNOLOGY AREAS: Air Platform

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT I: Joint Strike Fighter

OBJECTIVE: Develop and demonstrate full characterization of hot gas and steam ingestion phenomena as a function of aircraft configuration, operational environment (both inherent and induced), and surrounding influences. Develop and validate models capable of accurately simulating these unique environments and their influence on propulsion system operation and stability.

DESCRIPTION: In order to develop air systems with robust performance and safe operating procedures, it is necessary to represent the operational environments fully and accurately. To date, limited information is available to characterize the steam and hot gas environments encountered during carrier operations of a carrier-based aircraft and the hot gas environment encountered during vertical landings of a short takeoff/vertical landing (STOVL) aircraft. These subjects are of particular interest to the current Joint Strike Fighter (JSF) weapon system. Development of analytical methods (models) and affordable test techniques is needed to identify the influences of vehicle configuration, engine control system architecture, engine design characteristics, etc., such that these issues can be addressed early in the design cycle.

PHASE I: Define the available database of aircraft carrier catapult steam exposure environment and STOVL aircraft outwash/ground sheet environment. Using all available data, derive a validated analytical model of these environments that can be adapted to other configurations of interest. This should include bounding the database, identifying independent and dependent parameters of the phenomena, and developing methodologies for prediction of steam and hot gas ingestion levels.

PHASE II: Conduct further validation and verification of the final analytical models and theories with affordable test techniques. Testing must relate to the specific environments of the carrier operations (especially catapult takeoff) and vertical landings required of the JSF. This may involve full-scale surveys of the steam environment produced and this can be conducted with government involvement at land-based catapult assets.

PHASE III: During this phase, presentation of the models and procedures developed may be directed toward specific application to the JSF configuration. Cooperation with the JSF manufacturer is highly encouraged. This should include assessment of the engine operability and performance implications on the JSF configurations. Commercial application and availability of these models and procedures are advised during this phase.

PHASE III DUAL USE APPLICATIONS: These models are adaptable to the commercial environment for nacelle design, particularly with respect to ground clearance and thrust reverser design. Use of this capability will contribute to significant savings by allowing analytical solutions early in the design process.

KEYWORDS: Steam Ingestion, Hot Gas Ingestion, Internal Aerodynamics, Carrier Suitability, Carrier Operational Environment, Vertical Landing Environment

N02-148 **TITLE:** Reduced Emissions Fuel Nozzle

TECHNOLOGY AREAS: Air Platform

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT I: Joint Strike Fighter

OBJECTIVE: To develop a gas turbine engine fuel nozzle design that reduces emission of nitrogen oxides (NOx) and other pollutants.

DESCRIPTION: Current gas turbine combustors for large military engines (e.g., F119) use high shear fuel injectors. They operate at high combustor fuel-air ratios and high engine pressure ratios. These systems have been optimized for performance, combustor durability, and operability, but little emphasis has been placed on emissions other than smoke. Future trends now emphasize reduced NOx and CO emissions, as well as more durable fuel injectors to handle copper fuel contamination that leads to carbon fouling.

To reduce NOx emissions at high power conditions, a lean combustor design will be required, rather than the conventional rich burn-quick mix-lean burn combustor designs currently employed in military engines. In addition to lower NOx, lean combustors will also dramatically reduce liner heat loads caused by luminous radiation. Lean combustors will require as much as 70% of the combustor airflow to flow through the fuel injector, in contrast to the usual 25-30%. For such large amounts of airflow, new, innovative fuel injector concepts must be developed to provide adequate fuel-air ratio turndown. Particularly challenging is the requirement of a lean blowout combustor fuel-air ratio of 0.005 during rapid deceleration at altitude.
In this project, the Navy desires development of a fuel injector that reduces NOx, carbon monoxide (CO), unburned hydrocarbons (UHC), and particulate matter (PM) emissions to levels on par with legacy aircraft, while maintaining current levels of performance, durability, and operability. In addition, the fuel injector must have minimum fuel passages of at least 0.020 inch, and be thermally protected to allow full engine life while subject to copper contaminated fuel as seen from the aircraft carrier fuel supply (currently estimated at 250 ppb of copper).

PHASE I: Concept feasibility will be demonstrated using numerical analysis and prototype hardware testing. Single injector lean blowout testing at atmospheric pressure will be performed to demonstrate combustor lean blowout fuel-air ratio of 0.005. Perform a computational fluid dynamics (CFD) analysis to predict NOx and CO emissions reductions that meet project goals. Demonstrate the modeling ability to reduce NOx emissions by at least 50%. Initial thermal protection studies should be performed and engine compatibility issues addressed.

PHASE II: The fuel injector aero design will be optimized through single injector testing at engine conditions. Modeling and prediction of emissions will be revised as appropriate. Demonstrate the modeling ability to reduce NOx emission by 70%. The thermal design will be completed, and near engine-quality fuel injector hardware fabricated and tested for durability.

PHASE III: A set of engine-quality fuel injectors will be fabricated and tested in a multi-sector or full annular combustor rig test. The fuel injector will then be transitioned into a full engine test.

PHASE III DUAL USE APPLICATIONS: Emission reduction is important to all military and commercial gas turbine engines. The fuel injector developed in this project can be scaled for other military and commercial gas turbines. Transition to commercial engines is simplified by their less rigorous performance requirements.

REFERENCES:
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2. Graves, Charles B., "Outer Shear Layer Swirl Mixer for a Combustor," U.S. Patent 5,603,211; February 18, 1997.
3. Crocker, David S. et al., "Piloted Airblast Lean Direct Fuel Injector," U.S. Patent 6,272,840; August 14, 2001.
4. Mansour, Adel et al., "A New Hybrid Air Blast Nozzle for Advanced Gas Turbine Combustors," ASME Paper 2000-GT-117, May, 2000.
5. Tacina, Robert R. et al., "Flame Tube NOx Emissions Using a Lean-Direct-Wall-Injection Combustor Concept," AIAA Paper 2001-3271, July, 2001.
6. Zelina, J. and Penko, P.F., "Low-Emissions Gas Turbine Combustor for Regional-Class Aircraft," ASME Paper 2000-GT-0100, May, 2000.
7. Nickolaus, Daniel A., "Development of a Lean Direct Fuel Injector for Low Emission Aero Gas Turbines," ASME Paper GT-2002-30409, June, 2002.

KEYWORDS: Fuel Injector, Fuel Nozzle, Gas Turbine Combustor, Emissions, Durability, Environmental

N02-149 **TITLE**: High Fuel-Air Ratio (FAR) Combustor Modeling

TECHNOLOGY AREAS: Air Platform

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT I: Joint Strike Fighter

OBJECTIVE: Develop modeling tools that accurately predict aerothermodynamic conditions of gas turbine engine high FAR combustors.

DESCRIPTION: Military aircraft engines currently in development for the Joint Strike Force (JSF) program operate at FARs well above those currently in production. The physical and chemical characteristics of combustion at these temperature and FAR conditions are not well understood. Current equilibrium assumptions may not be valid when a significant portion of the combusting flow is at or above stoichiometric conditions. Improved modeling and predictive capabilities that take these issues into consideration are needed. Use of such models will improve the combustor design cycle by predicting combustor exit conditions more accurately and by allowing combustor design changes to be evaluated prior to test, leading to more efficient rig test programs.

PHASE I: Develop a combustor model applicable to a military gas turbine engine. Demonstrate the capability of the model to predict accurately theoretical combustor internal and exit conditions (e.g., efficiency, temperature profile, species concentration) for operation below stoichiometric levels. Extend the prediction to conditions where a substantial portion of the combustor volume is above stoichiometric conditions. Demonstrate the nonlinear change in combustor performance due to high FAR effects. Identify the pertinent parameters that have the most effect on performance.

PHASE II: Refine the model as necessary. Evaluate the accuracy of the model by comparing predictions to experimental data. Experimental data are to be obtained via sub-scale or sector testing, which maintains relevance to military gas turbine engine cycles. Prototype hardware must therefore be fabricated and tested or access to experimental data otherwise obtained. Demonstrate the capability of the model to predict experimental results at moderate and high overall FARs accurately.

PHASE III: Refine the model as necessary. Apply the model to a specific JSF engine or component. Demonstrate the model's capability to predict JSF combustor performance accurately, and verify by comparison to combustor rig and full engine test data.

PHASE III DUAL USE APPLICATIONS: This modeling capability would be applicable to any industry requiring high FAR combustion. Commercial aircraft engine and industrial gas turbines generally avoid near stoichiometric combustion for durability reasons but these markets may benefit nonetheless from the improvements in combustion modeling accuracy, leading to significant cost savings by allowing for analytical solutions early in the design process.

REFERENCES:
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2. Smiljanovski, Vanco and Brehm, Norbert, "CFD Liquid Spray Combustion Analysis of a Single Annular Gas Turbine Combustor," AMSE Paper 99-GT-300, June, 1999.
3. Mongia, H.C., et al., "Combustion Research Needs for Helping Development of Next Generation Advanced Combustors, " AIAA Paper 2001-3853, July, 2001.

4. Malecki, Robert E., et al., "Application of an Advanced CFD-Based Analysis System to the PW6000 Combustor to Optimize Exit Temperature Distribution- Part I: Description and Validation of the Analysis Tool," ASME Paper 2001-GT-0062, July, 2001.
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KEYWORDS: Modeling, Combustion, Fuel-Air Ratio (FAR), Stoichiometry, Equilibrium, Efficiency

N02-150 **TITLE**: Mid-Air Collision Avoidance System (MCAS) Data Fusion Methods

TECHNOLOGY AREAS: Air Platform

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT IC: PMA 299 Multi-Mission Helicopter Program Office

OBJECTIVE: Study and develop a data fusion algorithm to merge numerous MCAS data sources.

DESCRIPTION: Per the 9 November 1999 Navy N88 Safety Mandate, all new or retrofitted aircraft are required to have a collision avoidance system (CAS) capability. MCAS is being developed for Navy and Marine Corps fixed- and rotary-wing aircraft. The MCAS phase I system will use Mode-S automatic dependent surveillance-broadcast (ADS-B) downlink format (DF) 17 for collision avoidance purposes. MCAS phase 2 and 3 systems will merge received ADS-B information with data received from other systems such as Link-16, Mode-5, and traffic information service B (TIS B). The issue to be resolved is how to merge duplicate data references on one single aircraft into an accurate MCAS database. An algorithm of how multiple data tracks of a single aircraft can be merged into one accurate single track must be done for MCAS phases 2 and 3. It will also be necessary to develop a data fusion algorithm for MCAS needs. This supports the safety needs as defined by the Core Avionics Master Plan (CAMP) Safety Roadmap for knowledge of environment and asset protection.

PHASE I: Perform a technology feasibility assessment of the newer data fusion techniques and develop an initial data fusion algorithm between Link-16 and Mode-S for use on the MCAS.

PHASE II: Develop a robust data fusion algorithm for use on the MCAS, adding TIS B and Mode 5.

PHASE III: Integrate the data fusion algorithm into the operational MCAS software program.

PHASE III DUAL USE APPLICATIONS: DF17 ADS-B is a technology that the FAA and Europe are currently reviewing for use in commercial airlines. There are cargo company airlines currently using DF17 ADS-B. MCAS and the simulation program developed will be interoperable with commercial ADS-B DF17 systems if the FAA chooses to use ADS-B DF17 as a safety tool. This data fusion algorithm will be marketable to high-end commercial general aviation.

REFERENCES:
1. Naval Aviation Core Avionics Master Plan

KEYWORDS: Mid-Air Collision Avoidance (MCAS), Collision Avoidance System (CAS), Automatic Dependent Surveillance Broadcast (ADS-B), Mode S, Mode 5, Traffic Information Service B (TIS B)

N02-151 **TITLE:** Passive Noise Reduction Technology to Improve Speech Intelligibility and Reduce Noise for Pilot and Deck Crew Helmet Mounted Systems

TECHNOLOGY AREAS: Human Systems

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT I: Joint Strike Fighter

OBJECTIVE: New passive hearing protection/attenuation technology is needed to reduce ambient noise, which leaks past the ear seal and cup into the user's ear canal. New ideas and technologies are sought to improve the ear seal fit and ear plug designs to reduce or eliminate leakage for all military male and female head sizes in order to reduce or eliminate noise to the ear canal for both the aircrew or the deck crew personnel.

DESCRIPTION: Speech communications by the aircrew in the aircraft cockpit and on the deck are extremely difficult due to excessive background noise from the aircraft engine(s), environmental control system (ECS) equipment, and wind noise over the canopy or over the deck. Current U.S. military helmets use a circum-aural passive hearing protector consisting of an ear cup assembly with ear seal or pad and incorporate communication earphone elements at each ear cup to permit voice communication. In some cases, aviation personnel use double hearing protection by inserting foam ear plugs into the ear canal before donning their helmet with passive ear cup assemblies and the ear phone elements. As new high-performance aircraft are added to the Fleet, the noise generated by their more powerful engines are producing more noise both on the deck of the ship and in the cockpit. This makes speech intelligibility difficult and can cause permanent hearing damage to aviation personnel depending upon the exposure levels and the time of exposure. For the purpose of this program, 85 decibels absolute (dB(A)) for a maximum of 8 hours per day with 3 dB doubling will be used as the allowable threshold. This assumes that personnel will have at least 16 hours of "quiet time" each day. Deck crew personnel could be exposed to overall noise up to 150 dB(A) during aircraft launches with "after burner" operational and aircraft recoveries. Aircrew personnel in the cockpit could be exposed to noise levels up to 120 dB(A) caused by a combination of engine noise, ECS noise, and wind noise. Current deck crew helmets (cranials), when combined with off-the-shelf foam ear plugs, can provide up to approximately 30 dB(A) of protection. NAVAIR will provide reports of the latest noise measurements taken on the ground, on a carrier, and on LHA class ships to the successful bidder(s). A system approach that improves the passive hearing protection for users both with or without communications is desired. New approaches for passive technology are encouraged. Protective equipment that is easy to don and doff and fits the user with minimum training is very important. The goal of this program is to design combinations of different passive hearing protection technologies or new technologies to obtain at least 45 dB(A) attenuation.

PHASE I: Propose new passive approaches to hearing protection for Naval aviators and deck crew personnel. Develop a conceptual design and demonstrate the feasibility of a new passive hearing protection system for the deck crew personnel.

PHASE II: Develop detailed designs for the Phase I prototype and develop the corresponding prototype. Demonstrate that the aircrew hearing protective systems provide at least 38 dB(A) of passive attenuation for the aircrew personnel with communication systems, and a minimum of 45 dB(A) or higher of passive attenuation for deck crew personnel without communications. Final prototypes for each system configuration shall be fabricated and preliminary testing conducted to verify the speech intelligibility (per ANSI S3.2-1989 (R1999) and noise attenuation per ANSI S12.6-1997 (Real Ear Attenuation at Threshold) per Navy frequency specifications for the new passive protective designs.

PHASE III: The developed system(s) will be integrated into the existing helmets and tested in the Fleet. After successful demonstration and acceptance by the Fleet, transition this passive technology into the Fleet.

PHASE III DUAL USE APPLICATIONS: Commercial aircraft pilots and ground crew personnel need new hearing protective equipment. All the U.S. and foreign military personnel are in need of improved hearing protective equipment. Homeowners and commercial contractors operating heavy industrial equipment that generates excessive noise could also use the technology.

REFERENCES:

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2. ANSI S12.6-1997 "Methods for Measuring the Real-ear Attenuation of Hearing Protectors"
3. E-A-R 82-6/HP, "Bibliography on Hearing Protection, Hearing Conservation, and Aural Care, Hygiene and Physiology, 1831-1999", E.H. Berger, M.S., January 25, 1999
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5. Barrow, McKinley and D'Andrade, “Acoustical Noise Fields Generated on the Deck of the USS Nassau During Shipboard Operations of AV-8B Aircraft,” Report No. NAWCADPAX/TR-2000/20826, February 2001.

KEYWORDS: Hearing Protection, Passive Noise Reduction, Ear Plugs, Noise Attenuation, Speech Intelligibility, Improved Communications

N02-152 **TITLE**: Environmental Mission Planner – The Total Solution

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT IC: PMA 299 Multi-Mission Helicopter Program Office

OBJECTIVE: Design and develop an innovative total system solution for the tactical antisubmarine warfare (ASW) environmental mission planner that provides universal compatibility with minimal impact on existing and future aircraft and tactical support center based systems.

DESCRIPTION: ASW tactical missions require accurate knowledge of the environment to plan and conduct operations, especially in littoral areas where a highly dynamic and variable environment severely complicates mission planning and the conduct of naval operations. The Navy is developing a two-part system composed of an expendable environmental measurement sonobuoy and tactical decision aid (TDA) linked with environmental databases that will interact with the ASW warfighter onboard an aircraft and at a ground station. This topic will focus on all parts of the environmental collection efforts except the environmental measurement sonobuoy. The TDA will support preflight planning and in-flight near real-time updates measured by the sonobuoy or retrieved from established environmental data base architectures.

The Tactical Acoustic Measurement (TAM) Program is interested in investigating an innovative total system solution that makes efficient use of available subsystems and that ties the sensor, TDA, and databases, calculation time, and data assimilation together in the most cost-effective means to support the warfighter. In addition, sufficient information must be presented to allow the operator to understand the reasoning behind the recommendation. Of prime importance is an on-station computational quick solution that is non-interfering with existing platform software. However, an innovative total system design must also take into account the preflight, on-the-ground mission planning, which uses various existing Navy decision aids and databases. The design must investigate cross-platform compatibility, cross-platform networking, web-enablement, and efficient code development/reuse. Finally the total system solution must include the assimilation of in-situ data into existing environmental databases.

PHASE I: Characterize various designs, show advantages and disadvantages, and identify risk areas. Discuss tradeoff between cost and measurements. Select optimum system design concept(s) for development in Phase II.

PHASE II: Develop Phase I recommended technology(s) and hardware design. Assemble a prototype and conduct a demonstration of the total capability. Finalize the concept design and make recommendations for Phase III production-oriented designs.

PHASE III: Develop production design of Phase II solution in TAM sonobuoy system. Conduct integrated testing.

PHASE III DUAL USE APPLICATIONS: Technology transition to the U.S. Navy's TAM sonobuoy system is expected. An environmental mission planner could also be used within the oil-drilling and mineral-mining industries and could support underwater target detection efforts in search and rescue missions.

REFERENCES:
1. Flynn, D. F., "Tactical Acoustic Measurement and Decision Aid Environmental Sonobuoy Program," 26 October 2000

KEYWORDS: Antisubmarine Warfare, Tactical Acoustic Measurement Sonobuoy, Bathythermograph Measurement Device Replacement, Tactical Decision Aid, Tactical Environmental Database, Mission Planner

N02-153 **TITLE**: High-Efficiency Plasma Sparkers for Navy Applications

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT IC: PMA 299 Multi-Mission Helicopter Program Office

OBJECTIVE: Develop and fabricate efficient, low-cost sparker technology for use in ocean environmental measurements, electromagnetics, acoustic/electromagnetic countermeasures, force protection visual trip wires, and anti-biofouling.

DESCRIPTION: Under previous SBIR contracts, the Navy and Army Corps of Engineers have focused on technology that is essential for the development of cost-effective, high-efficiency sparker technology for use in ocean environmental measurements, electromagnetic countermeasures, and anti-biofouling. The sparker is an electrically driven impulsive technology that in water emits a series of strong pressure pulses, similar to explosives, and in air creates a broad electromagnetic interference as well as a blinding light. The focus of the Navy and Army Corps of Engineers has been on increased source level in a fixed package. A successful demonstration of the technology in salt water has produced acoustic source levels of 197 dB (ref. uPa ^2 @ 1 m, ref. 1 sec) [see ref. 1] in an A size (4.875-inch-diameter by 36-inch-long) sonobuoy form factor. The technology goal for this SBIR is an increase in the source level by 6 dB while reducing the form factor to 1/3 A size (4.875 inches by 12 inches long). Emphasis should be placed on, but not limited to, emerging capacitor and other energy storage devices, energy focusing techniques, and exothermal enhancements. Since the final developed sparker circuit module must be mass-produced in an expendable sonobuoy system, emphasis on cost is paramount. Innovative design goal costs must not exceed $200 per 80,000 units.

PHASE I: Develop a conceptual design for an efficient, low-cost sparker that meets Navy requirements. Include methodology and performance levels that will demonstrate the proposed concept at the energy levels discussed above.

PHASE II: Develop detailed designs for the Phase I efficient, low-cost sparker, and fabricate a circuit for proof-of-concept testing. Develop a hardened-for-sea sparker circuit prototype. Conduct preliminary testing in a laboratory and at sea, and report the results of this preliminary testing.

PHASE III: Develop production design and integrate it into Navy/Army systems upon meeting requirements.

PHASE III DUAL USE APPLICATIONS: Potential commercial use is for control of the Zebra mussel. The Zebra mussel (Dreissena polymorpha) is a small freshwater mussel that was accidentally introduced into the Great Lakes from Europe in the late 1980s. Because it tolerates extreme crowding, it can clog intake pipes, filters, trash racks, and other components of ships, dams, pumping plants, and hydropower facilities that use freshwater. These mussels can be controlled by use of a plasma sparker (Mackie et al. 1999, Welch et al. 2000). This device works by releasing stored electrical energy between two submersed electrodes that either kill the mussels directly or inhibit their settlement when they transition from the veliger (larval) stage. The plasma sparker is an environmentally benign method and can be used when chemicals, hot water, or filters cannot be used to control these pests.

REFERENCES:
1. Raymond Schaefer and D. Flynn, "Development of a Sonobuoy Using Sparker Acoustic Sources as an Alternative to Explosives," Oceans '99, MTS/IEEE. Sept. 99

KEYWORDS: Sparker, Low-Cost, Zebra Mussel, Antisubmarine Warfare, Tactical Acoustic Measurement Sonobuoy, Bathythermograph Measurement Device

N02-154 **TITLE:** Water Column Sound Velocity Sensor Package

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace Environment

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: PMA 299: Multi-Mission Helicopter Program Office

OBJECTIVE: Develop a water column sound velocity measurement sensor package.

DESCRIPTION: Anti-Submarine Warfare (ASW) tactical missions require accurate knowledge of the environment to plan and conduct operations, especially in littoral areas where a highly dynamic and variable environment severely complicates mission planning and the conduct of naval operations. Sensor packages for measuring oceanographic variables are under development, which are rapidly deployable, expendable, and radio-linked to command and control decision makers.

The Tactical Acoustic Measurement Program (TAM) is interested in investigating innovative mechanical sensor(s) designs that measure the ocean temperature or sound speed from the surface to a depth of 300 meters. This sensor shall be capable of sensing the environment for three days from initial deployment. The innovative design must grow the technology of micro sensors and/or cabling while focused on cost as well as the overall packaging size. Overall sub-unit cost including sensor shall be on the order of $125 for the 80,000 unit. Overall pre-deployed dimensions of the subunit shall not exceed a dimension of 2.0 inch diameter x 10.0 inch long right circular cylinder and a weight of 2.0 lbs. Designs envisioned include, but are not limited to, sound velocity probes or thermistor or velocity string embedded in sonobuoy suspension cable or a separate sensor string unit tethered from the surface float. Other designs, which would be acceptable, would include, but are also not limited to, a single sound velocity probe or thermistor deployed and recovered and redeployed at regular intervals through the water column.

PHASE I: Characterize various designs and investigate deployment technology for use in an A-size sonobuoy. Discuss trade off between cost and measurements. Select material(s), component (s) and hardware design concept(s) for development in Phase II.

PHASE II: Develop deployment technology and hardware design. Assemble a prototype sub system, which interacts with existing buoy designs, and conduct a demonstration measurement capability. Finalize the concept design and make recommendations for Phase III production oriented designs.

PHASE III: Production design and integration of sub module in TAM sonobuoy system. Conduct integrated testing.

PHASE III DUAL USE APPLICATIONS: Technology transition to the U. S. Navy's Tactical Acoustic Measurement Sonobuoy system is expected.

KEYWORDS: Sound Speed, Ocean Water Temperature, Thermistor String, Tactical Acoustic Measurement Sonobuoy, Bathythermograph Measurement Device, Water Column Profiler

N02-155 **TITLE:** Nano-Grain-Size Infrared Window Materials

TECHNOLOGY AREAS: Materials/Processes, Sensors, Electronics, Battlespace

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: PMA 272 – Advanced Tactical Aircraft Protection Program

OBJECTIVE: Fabricate optical-quality, infrared-transparent windows with a grain size of 50 nanometers or less and mechanical strength at least twice as great as that of conventional varieties of the same materials.

DESCRIPTION: Windows for infrared sensors on missiles and aircraft must be of high optical quality and durable enough to protect the delicate sensor from harsh environmental conditions. Mechanical and thermal shock capabilities of windows are limited by their mechanical strength, which in turn is related to the grain size in these polycrystalline materials. Over some range of grain size, decreasing the grain size of a polycrystalline ceramic increases its mechanical strength. Thermal shock resistance, rain impact resistance, and projectile impact resistance all increase in proportion to mechanical strength. By contrast, the optical quality of polycrystalline ceramics tends to decrease with decreasing grain size because of impurities and second phases concentrated at grain boundaries. Pure materials with very clean grain boundaries are likely to be required for good optical quality in nano-grain materials. Composite compositions normally produce too much optical scatter to be used as optical materials. If the grain size is sufficiently smaller than the wavelength of light to be transmitted, composite optical materials with unprecedented mechanical properties might be possible.

Goals for materials to be made under this program: (1) The same low infrared optical absorption coefficient as conventional varieties of the same material in the midwave (3-5 micrometer (μm) wavelength) and long-wave (8-10 μm wavelength) infrared spectral regions should be retained. (2) Total integrated optical scatter at infrared wavelengths should not exceed 2 percent. (3) Mechanical strength should be at least twice as great as that of conventional varieties of the same material. (4) Thermal conductivity should not decrease from that of conventional material. Fabrication procedures used to make optical materials must be scaleable to produce windows and domes up to 75mm in diameter. Examples of desirable materials include yttria, spinel, aluminum oxynitride (ALON), magnesium fluoride, alumina, and zinc sulfide. New, composite compositions with optical transparency may also be enabled by the nano-grain size. Successful proposals will provide convincing rationale for how grain growth during densification will be prevented.

PHASE I: Demonstrate a method to make fully dense, infrared-transparent material with a grain size of 50 nanometers or less. Infrared transmission should be within 2 percent of that of conventional forms of the same material. Specimens fabricated in Phase I should be at least 1 cm in diameter and 2mm thick. The government will measure total integrated infrared scatter at either 3.39 or 10.6 μm wavelength for up to four specimens fabricated at various times by the contractor.

PHASE II: Optimize the fabrication process for the best tradeoff between maximum infrared transmission, minimum infrared optical scatter, and maximum strength. Conduct periodic measurements of transmission and mechanical strength to monitor the progress of process development. To aid in process development, the government will measure total integrated infrared scatter at either 3.39 or 10.6 μm wavelength at times agreed upon with the contractor. Demonstrate scale-up of optical quality material to a diameter of 50mm and a thickness of 2mm. By the end of Phase II, measure the equibiaxial flexure strength at 25°C of 20 disks with a diameter of 25mm and thickness of 1mm. Measure optical properties of disks with a thickness of 2mm.

PHASE III: Demonstrate commercial production capability of infrared windows and hemispheric domes up to 75mm diameter. Scale up strengthened optical materials for use in transparent armor (bulletproof windows). Using the new process, produce high optical quality, high mechanical strength, infrared optical components for Navy, Air Force, and Army weapon and aircraft sensor systems.

PHASE III DUAL USE APPLICATIONS: The material could be of value for bulletproof windows and high-temperature windows for sensors to monitor industrial processes.

REFERENCES:
1. D. C. Harris, Materials for Infrared Windows and Domes, SPIE Press, Bellingham WA, 1999.

KEYWORDS: Infrared Window, Nanomaterial, Ceramics, Yttria, Spinel, Aluminum Oxynitride (ALON)

N02-156 **TITLE:** Compact, High-Efficiency, Eye-Safe, Fiber Laser for LADAR Applications

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT IC: PMA 280 - Tomahawk All-Up-Round Program

OBJECTIVE: Develop and fabricate a compact (<20 cubic inch, including all drive and control electronics) 50-kHz pulse repetition frequency (PRF), 10-watt, eye-safe laser for laser radars (LADARs) planned for missile, unmanned aerial vehicle (UAV), and aircraft applications. High-efficiency, direct transition processes must be used to generate the required high levels of optical output power in the eye-safe spectral region, such as those found in fiber lasers.

DESCRIPTION: Previously, ONR and NAVAIR have focused on technology that is essential for the development of cost-effective laser systems for Navy applications in missiles and aircraft. The development of solid-state lasers, that serve as sources for laser radar systems, laser designators, and laser-countermeasure systems, and that can provide the required performance, are limited by their low efficiency. In these laser systems, the diode pump radiation generates lasing in a solid state material like Nd:YAG, Nd:YVO4, Nd:YLF, and Yb:SFAP. The radiation produced is ~1 micron that through an inefficient nonlinear optical process is converted to the 1.5 micron, “eye-safe”, spectral region. The overall efficiency of these lasers is on the order of 10%. For applications where the prime power and cooling are limited, this low efficiency makes this type of laser system is not practical.

With the new advances in diodes and fibers, the potential for direct conversion of diode pump radiation to the eye-safe spectral region via fiber lasers is now becoming realized, specifically with Erbium fibers. But all is not complete. Cost of any laser system must continue to be lowered and performance increased to meet future Navy requirements. The current projected cost of this 10 watt fiber laser in production must not exceed $5000, depending upon quantity purchased. This will allow the overall cost of the seeker under consideration for the laser radar for the Cruise Missile Real Time Re-Targeting (CMRTR) Program to be realized. This same laser system would find application in UAV's and with modification, to eye safe target designation for future aircraft such as JSF and in legacy aircraft such as F/A-18. Examples of current systems under development that can benefit from this technology are: Tactical Tomahawk, and Marine/Army UAV programs.

PHASE I: Develop a conceptual design for an efficient, 50 kHz PRF nominal (20-100 kHz goal), 12 ns pulse width nominal (8-15 ns goal), 10 watt fiber laser at the 1.5 micron spectral region with a M2 goal of < 1.2 that meets Navy requirements of size, cost, and efficiency (see Reference below). Prototype performance that will demonstrate the proposed concept at the power and wavelength above will be required.

PHASE II: Develop detailed, cost effective, designs for the Phase I efficient, 50 kHz PRF, 10 watt, 1.5 micron fiber laser and fabricate fiber lasers suitable for proof-of-concept testing, including environmental testing. Conduct preliminary testing in a commercial laboratory and in government laboratories, and report the results. Testing in a government laboratory will be at no cost to the SBIR contract.

PHASE III: Scale up for mass production of the advanced fiber laser. These efficient, low-cost fiber lasers, upon meeting Navy requirements, will be transitioned into several weapon acquisition programs.

PHASE III DUAL USE APPLICATIONS: This product would directly support commercialization of LADAR for numerous industrial, commercial, and scientific applications. Included among the applications for commercial LADAR are terrain mapping, generation of three-dimensional models, computer graphics, graphic arts, and cinematography and special effects.

REFERENCES:

1. Cruise Missile Real Time Re-Targeting Program (CMRTR) Laser Source Requirements Document. This document will be provided to potential contractors upon request.

KEYWORDS: Laser Radar, Laser Diodes, Low Cost, High Efficiency, Fiber Lasers, Erbium

N02-157 **TITLE:** High-Permeability Magnetic Material

TECHNOLOGY AREAS: Materials/Processes

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: PMA 251 – Aircraft Launch and Recovery Equipment

OBJECTIVE: Develop cost-effective, high-permeability magnetic materials for use in electromagnetic and electromechanical devices, allowing higher power and energy densities.

DESCRIPTION: The Navy is interested in pursuing material technologies to provide cost-effective, high-permeability magnetic material that could operate in the 2.2-2.5 Tesla range without saturating. Such technologies could be transitioned to the electromagnetic aircraft launch system (EMALS) program, which seeks to replace current steam catapults aboard aircraft carriers with an electromagnetic means of launching aircraft. In order to be viable for this application, the material must not exceed three times the cost of traditional silicon steel (such as M-19), and be similar enough in its mechanical properties to silicon steel to allow it to be used in electromagnetic and electromechanical devices. In addition, it must be able to operate with flux densities of 2.2-2.5 Tesla without saturating. Materials that exhibit these characteristics could significantly reduce the weight and volume of electrical motors and generators, thereby reducing the weight of the ship and its center of gravity, making the ship more stable and buying back service life allowance.

PHASE I: Assess the feasibility of developing innovative materials that would meet the requirements described above. Prove, through analysis and hardware demonstrations, that the concept(s) could meet the stated requirements.

PHASE II: Demonstrate a small-scale electric motor that uses the high-permeability material and verify its performance advantage. Demonstrate the cost and produceability of the material.

PHASE III: Produce a full-scale linear motor that could be tested at the EMALS test site at NAVAIR Lakehurst. A successful material could be integrated into EMALS aboard future carriers.

PHASE III DUAL USE APPLICATIONS: High-permeability magnetic materials could have a profound effect on the commercial sector. These materials could provide for higher power and energy dense motors and generators, thereby reducing their size and weight. This is important to the future of locomotives, aircraft, spacecraft, and electric vehicles. While high-permeability magnetic materials exist, they are cost-prohibitive for all but the most extreme uses. A new, cost-effective material would open many applications to the benefits mentioned previously.

KEYWORDS: High Permeability, Electromagnetic, Aircraft Launch System, Silicon, Electromechanical, Electrical Motors

N02-158 **TITLE:** High-Strength, High-Toughness Stainless Steel

TECHNOLOGY AREAS: Materials/Processes

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT I: Joint Strike Fighter

OBJECTIVE: Develop a high-strength, high-toughness stainless steel, employing theoretical alloy design and experimental verification approach.

DESCRIPTION: The requirements for carrier-based aircraft components are stringent. These components must withstand repeated loading of large magnitudes and corrosion attack in aggressive environments: humid, salt-laden air; saltwater spray; and sulfur dioxide from stack gas and aircraft engine exhaust. To meet such requirements, high-strength, low-alloy steels were initially used for aircraft components in the late 1950s and early 1960s. However, these steels are considered to have low fracture toughness and are highly susceptible to hydrogen embrittlement and corrosion. In the 1960s, a much higher strength steel, 300M, was introduced. The higher strength permits lighter aircraft components but the higher strength without a corresponding increase in fracture toughness results in a small critical flaw size and inferior damage tolerance. Corrosion resistance is also quite poor. However, 300M steel was the material of choice for most aircraft components requiring high strength in the 1970s and 1980s. In 1990, a new and better steel, AerMet 100, was developed. This steel has a combination of high strength, 1965 MPa (285 ksi), and high fracture toughness, 126 MPa$\sqrt{m}$ (115 ksi$\sqrt{in}$). AerMet 100 is currently used for F/A-18E/F aircraft main landing gear, nose gear, arresting gear, horizontal stabilator spindle, wingfold transmissions, wing pivot pins, etc. However, it is still susceptible to corrosion and hydrogen embrittlement and the components, such as landing gear, must have costly protective plating. In order to achieve higher performance and greater reliability at minimum life-cycle cost, future aircraft (military or civilian) components, such as landing gear, should be made of a new material that is superior to any currently available steel. This new material must have a high level of corrosion resistance, requiring no protective plating that pollutes the environment, and high strength and toughness. (Chromium-electroplating bath contains hexavalent chromium, a human carcinogen.)

PHASE I: Conduct metallurgical design and preliminary property characterization of a high-strength, high-toughness stainless steel, requiring no protective plating. This steel should also have tensile strength of 1965 MPa (285 ksi) and fracture toughness of 125 MPa$\sqrt{m}$ (115 ksi$\sqrt{in}$) or better.

PHASE II: Produce, on a laboratory scale, a few chosen candidate steels. Evaluate the microstructure, corrosion resistance, and mechanical properties. Select the optimum high-strength, high-toughness stainless steel and establish the essential heat treatment process.

PHASE III: Produce the optimum high-strength, high-toughness stainless steel commercially. Verify its superiority of corrosion resistance and mechanical properties. Transition the new technology to military and commercial application.

PHASE III DUAL USE APPLICATIONS: The high-strength, high-toughness stainless steel has application potential for commercial aircraft components, marine structures, chemical equipment, fasteners, tools, etc. requiring corrosion resistance, strength, and toughness.

KEYWORDS: Design, Aircraft Component, Landing Gear, Steel, Corrosion Resistance, Protective Plating

N02-159 **TITLE:** Digital Motion Imagery (MI) Manipulation for Unmanned Aerial Vehicles (UAVs)

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT II: PMA 263 – Navy Unmanned Aerial Vehicles Program

OBJECTIVE: Develop a software tool to improve the UAV's capability to handle digital MI.

DESCRIPTION: The Tactical Control System (TCS) provides the military services with a single command, control, data receipt, data processing, data export and dissemination system that is interoperable with vertical takeoff and landing tactical unmanned aerial vehicles (VTUAV). The Joint Technical Architecture (4.0) and the Motion Imagery Standards Profile (1.6) are driving the requirements for the VTUAV and TCS to move from the analog video to MI. The Navy requires a software product that can:

- Display the digital MI to screen with minimal latency
- Archive digital MI to include searching of the data by time and/or location
- Generate national imagery transmission formats (NITF) from DoD approved motion imagery compression format (MPEG-2) software
- Generate MI clips for dissemination
- Annotate the digital MI
- Develop mosaics from the digital MI

Although there are commercial products that manipulate MI, the products have unacceptable latency for displaying the MI to the screen for Navy applications. The VTUAV and TCS are looking for an innovative solution for the digital MI latency problem. The VTUAV system with its 12-hour mission will generate massive amounts of data. The Navy needs a way to store these data and a way to retrieve them quickly.

PHASE I: Determine the feasibility of running the proposed software on a work station that takes MPEG-2 transport with metadata running at 8 Mbits and displaying it on the screen using software-only decoding. The software should be able to read the Metadata and annotate the imagery with information, as it is being displayed, store 12 hours of motion imagery, and search the stored motion imagery for the time and location of the imagery.

PHASE II: Develop the software to meet the Navy requirements defined in the description. Build a prototype to demonstrate the software's capability to work with TCS software. Minimize the latency from receipt of the motion imagery to displaying the motion imagery on screen.

PHASE III: Transition the software into the defense information infrastructure common operating environment.

PHASE III DUAL USE APPLICATIONS: In the growing market for UAVs and unmanned combat air vehicles (UCAVs), immediate customers for these products/technologies include both military and commercial markets. The archival capability has application for security cameras. With proliferation of home digital camcorders, a software package that manipulates that imagery has a potential market.

REFERENCES:

1. Joint Technical Architecture (4.0), http://www-jta.itsi.disa.mil
2. Motion Imagery Standards Profile (1.6), http://www.ismc.nima.mil/vwg/index.html
3. ISO/IEC 13818-1:2000, Information technology—Generic coding of moving pictures and associated information: Systems, dated December 14, 2000

KEYWORDS: Video Exploitation, MPEG-2, Digital, Motion Imagery (MI), Latency, Unmanned Aerial Vehicle (UAV)

N02-160 **TITLE:** Intelligent Advisor for Multi-Modal Human-Computer Interface (HCI) Design

TECHNOLOGY AREAS: Human Systems

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: PMA 282 – Cruise Missile Weapons System Program

OBJECTIVE: Create an innovative approach for providing intelligent advice in HCI design interactively.

DESCRIPTION: The Navy seeks an innovative concept and advanced intelligent system technologies that can provide HCI design advice. Today the design of an HCI is very dependent on the expertise and diligence of the HCI design team, which typically attempts to follow principles of HCI design derived from research in human-computer interaction. Creating an HCI design involves such issues as information representation, information and interaction component placement, color usage, attention management and alerting schemes, and navigation through a user's tasks. This is further complicated when choices among multiple modalities of interaction with users (e.g., mouse speech or visual display alone versus a combination of synthetic speech and visual output) must be made. In addition, most tactical Navy systems involve multiple users, are dynamic, have real-time components, must address safety aspects, and are mission critical. In the HCI design process, a number of diverse human-computer interaction principles must be applied to the domain of the objective system. This topic seeks to advance the state of the art in advising intelligent system technologies by creating and demonstrating a capability to provide HCI design advice interactively. As an HCI is being designed from components, the intelligent advisor would advise the designer on all aspects of the HCI by incorporating knowledge of basic human-computer interaction principles and the results of many years of research on the application of those principles. The advisor should be capable of learning, so that relevant advice can be provided during an iterative HCI design process, where the results of usability testing are incorporated in the design. It should also consider user-specified constraints on the HCI design, e.g., a small display surface in the case of a personal digital assistant (PDA) or the availability of a speech interface mechanism.

PHASE I: Devise an innovative concept for an interactive, intelligent advisor for designers of HCI for dynamic, real-time, multi-user, and mission-critical systems.

PHASE II: Create and demonstrate a prototype of the Phase I concept by applying intelligent system technologies in order to advise users on multi-modal HCI design interactively.

PHASE III: Mature the prototype of this capability for use in the development of software for upgrades to the tactical Tomahawk weapon control system (TTWCS).

PHASE III DUAL USE APPLICATIONS: The commercial world today uses an iterative usability engineering approach to develop HCI software. In addition, the use of speech dialog and other modalities of interaction are increasing as supporting technologies (e.g., speech recognition) mature. As a result, the potential commercial market for an interactive, intelligent, and multi-modal HCI design advisor is very large. In addition, numerous military systems would benefit.

REFERENCES:

1. S. Luz and N.O. Bernsen, "A Tool for Interactive Advice on the Use of Speech in Multimodal Systems," Journal of VLSI Signal Processing, Vol. 29, 2001, pp. 129-137.

KEYWORDS: Human Computer Interface, Usability Engineering, Intelligent Systems, Intelligent Advisor, Multimodal, Human-Computer Interaction

N02-161 **TITLE:** Hybrid Integrity for Precision Guidance and Landing

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT I: Joint Strike Fighter

OBJECTIVE: Develop very high-integrity global positioning system (GPS)-inertial navigation system (INS) techniques that meet requirements for airborne navigation and landing as well as high assurance of weapons delivery accuracy. These algorithms and techniques shall apply to both GPS anti-jam (AJ) stand-alone integration with INS, as well as short baseline kinematics relative to another GPS-INS.

DESCRIPTION: INS-GPS hybrid algorithms exist but are not optimized for high-integrity precision applications. Improvement in the state of the art is needed in three critical areas:

- First, GPS-INS integrity algorithms do not take into account the impact of GPS anti-jam operation. Current GPS systems lose accuracy under conditions of jamming as code measurements are degraded, carrier measurements are degraded and then denied, and the number of satellites being tracked is reduced. The joint precision approach and landing system (JPALS) and several weapon programs are developing GPS technologies that achieve higher AJ protection without sacrificing code and carrier measurement quality, but these do not take into account explicit use of the INS for integrity, continuity, and availability. Novel approaches are needed to achieve the necessary integrity performance with INS-GPS hybrids.

- Second, integrity schemes have not yet been explored to the required alarm limits for precision applications such as precision landing (1 meter alarm limit aboard ship, 5 meters ashore) and precision weapons requirements (typically 3m). These must be assured with a very low probability of undetected error (10-7) and high continuity (104) and availability (99.8+%).

- Third, research is needed to take into account compatibility with relative kinematic systems such as JPALS and short baseline kinematic approaches used for synthetic aperture radar (SAR) and target mensuration. Kinematic techniques, in particular, are computationally intensive, so the solutions are propagated forward in time to the last valid inertial measurement. Integrity schemes need to be explored for kinematic carrier phase techniques (KCPT) integration and propagation.

PHASE I: Identify new innovative approaches and algorithms to improve the integrity of GPS-INS systems using advanced AJ technology, very tight precision integrity thresholds, and kinematics. Consider all ranges of loose to very tight INS integration, as well as evaluations of the quality of the required GPS and INS sensors. The proposed integrity algorithms must be supported by a failure mode analysis that considers the effects of sensor and signal-in-space failures including GPS outages, subtle GPS failures including performance degradation caused by jamming, and INS failure modes. Continuity and availability must be considered in the analysis. Based on these analyses, propose approaches for further examination.

PHASE II: Develop a prototype of the most promising approaches in order to demonstrate that the integrity capability is realizable in a relevant environment. The prototyping shall include options to integrate with multiple sensor types for evaluation, including potential government-furnished equipment (GFE).

PHASE III: Mature and integrate the concepts and algorithms with prototype JPALS GPS-INS equipment and candidate weapon systems for evaluation.

PHASE III DUAL USE APPLICATIONS: The capability to provide high-integrity GPS-INS systems for precision applications has immense potential for commercial and military customers. Use of developed techniques has direct application to avionic systems for Federal Aviation Administration precision navigation and landing. Additional applications exist in land and urban navigation, especially as these techniques apply to using lower grade inertial instruments and C/A code GPS receivers.

REFERENCES:

1. Joint Precision Approach and Landing System (JPALS) Test and Evaluation Master Plan
2. RTCA DO-229C, Appendix R, Requirements and Test Procedures for Tightly Integrated GPS/Inertial Systems

KEYWORDS: Integrity, Kinematic Carrier Phase Techniques, Inertial Systems, Global Positioning System (GPS), Anti-Jam, Precision Approach

N02-162 **TITLE**: Innovative Erosion-Resistant Coating Materials/Concepts for Leading Edges on Composite Rotor Blades

TECHNOLOGY AREAS: Materials/Processes

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT IC: PMA 275 - V-22 (Osprey) Program

OBJECTIVE: Develop high-strain, lightweight, and conformable coating materials/concepts to improve the erosion resistance of the leading edges on composite rotor blades.

DESCRIPTION: Naval aircraft operate in hostile environments that include sandy or dusty landing zones and/or severe sand/rain storms. Helicopters and other vertical/short takeoff and landing (VTOL/STOL) aircraft such as the V-22 Osprey are expected to endure these severe environments without rapid erosion to the leading edge of their rotor blade. To avoid rapid deterioration of the rotor blade and potentially irreparable damage, typically the leading edge is protected with erosion-resistant materials. For example, the leading edge of the V-22 rotor blade is made of titanium and nickel abrasion strips bonded to the composite substrate (blade). Although effective for erosion protection, this metal and composite hybrid configuration limits working strain and fatigue life. This hybrid concept also hampers field serviceability and increases the operating and support cost of the rotor blade by inhibiting removal and replacement of the leading edge. It also necessitates frequent inspection to detect incipient fatigue cracks in the metal to ensure flight safety. The U.S. Navy is interested in removing the metallic leading edge strip and replacing it with innovative erosion-resistant coating materials/concepts directly over the composite leading edge of the rotor blade. This proposed concept helps reduce the overall blade weight and ensures uniform working strain and satisfactory fatigue life in the rotor blade. In the case of the V-22, the proposed coating materials/concepts will need to meet the SD-572 requirement for 250 hours continuous operation in rain, dust, and sand. Specifically, the proposed coating materials/concepts need to demonstrate a superior resistance to surface abrasion and cavitation caused by high-velocity impact of sand particles and raindrops, respectively. Furthermore, the contractor will need to demonstrate the efficacy and field serviceability of the proposed coating materials/concepts.

PHASE I: Provide an initial development effort that demonstrates the scientific merit and feasibility of an erosion-resistant coating for the composite leading edge. The proposed coating must be compatible with current composite blade materials and not degrade other performance requirements of the rotor blade.

PHASE II: Optimize the proposed coating materials/concepts, and fabricate and conduct appropriate coupon and component level experiments that mimic typical severe sand and rain erosion requirements. Demonstrate field serviceability and ease of application and removal. Demonstrate producibility and cost effectiveness of the proposed concept.

PHASE III: Implement full-scale production of the proposed coating materials/concepts to the rotor blade, and in concert with a major Navy rotor blade manufacturer, qualify and transition this technology to a rotary-wing platform.

PHASE III DUAL USE APPLICATIONS: Successful development of innovative coating materials/concepts for composite leading edges of rotor blades can reduce total ownership cost by reducing acquisition and operation costs and improving field serviceability. This technology is equally applicable for both commercial and DoD aircraft needing improved erosion-resistant surfaces.

REFERENCES:

1. S.C. Hong and T.J. Wiggins, "Advanced Rain and Sand Erosion Resistance Elastomers," Proceedings for the American Helicopter Society, 57th Annual Forum

KEYWORDS: Coatings, Sand Erosion, Rain Erosion, Leading Edge, Rotor Blade, Composites

N02-163 **TITLE:** Gas Turbine Engine Particulate Matter Measurement

TECHNOLOGY AREAS: Air Platform

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT I: Joint Strike Fighter

OBJECTIVE: Develop new and innovative testing technologies and methods for the determination of particulate emission mass from a gas turbine engine

DESCRIPTION: As a result of the Clean Air Act and the Environmental Protection Agency (EPA) National Standards, research objectives have been established to reduce the production of gaseous emissions as well as particulate matter emissions. With the delivery of the F/A-18E/F Super Hornet and the Joint Strike Fighter (JSF) to Navy and Marine Corps Air Stations around the country, new, more innovative means by which to measure gas turbine engine emissions are needed. The Air Stations must be able to test the efficacy of emission-reduction technologies already in place on engines to ensure that emissions of ozone precursors and particulate matter do not violate levels set in the National Ambient Air Quality Standard (NAAQS). The NAAQS has a health-based regulation for particulate matter with diameters less than 10 micrometers (PM10).

Currently, EPA Method 5 is used to measure the mass of the particulate emissions. However, this method is designed for particulate emissions from stationary emission units such as power plants. When applied to gas turbine engines, EPA Method 5 proves to be time consuming and impractical. The purpose of this SBIR is to develop new and innovative methods and technologies for emission particulate measurements geared towards gas turbine engines. The desired outcome of the new testing methods and technologies will be a direct mass measurement or a correlation to a mass measurement of exhaust particulate matter.

PHASE I: Conduct feasibility and technical merit demonstration. Investigate possible new testing methods and technologies for a direct measurement of mass or a correlation to a mass measurement of basic/generic gas turbine engine exhaust particulate matter. Initial ideas may be based on the combustor component only. Identify pertinent parameters that have the greatest influence on collecting a measurable, representative sample that is statistically significant.

PHASE II: Develop the most feasible testing methods and technologies. Conduct experimental verification. Refine, as necessary. Experimental data may be obtained via component-level rig testing or engine testing, if possible. To do this testing, combustor hardware must be fabricated or obtained, or access to an engine must be attained. Evaluate the efficiency of the testing methods and technologies by comparing collected data to historical experimental data. Identify one candidate method and technology that will be evaluated during a full-scale engine test in Phase III.

PHASE III: Apply new testing techniques and method to a JSF engine or other suitable fighter aircraft engine from Phase II. Refine the testing method and technologies, as necessary. Apply the new technologies and methods to an actual full-size engine test on the engine type chosen. Verify the capabilities of the technologies and method through efficiency, effectiveness and reliability.

PHASE III DUAL USE APPLICATIONS: Emission reduction is important to all military and commercial gas turbine engines. The testing technologies and methods developed in this project can be directly used to test other military and commercial gas turbines. Programs such as NASA's Ultra Efficient Engine Technology (UEET) could easily incorporate this technology.

REFERENCES:

1. National Ambient Air Quality Standard (NAAQS)
2. EPA Fact Sheet, 29 Nov 1996
3. Environmental Protection Agency Method 5 “Determination of Particulate Emissions from Stationary Emissions Units (by Liquid Impingement).”

KEYWORDS: Emissions, Particulate Matter, Method 5, Combustion, Gas Turbine Engine, Environmental Protection Agency

N02-164 **TITLE:** Precision Geo-Location for Turreted Electro-Optic Sensors

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT II: PMA 290 - Maritime Surveillance Aircraft (MSA) Leadership Program

OBJECTIVE: Develop a method of improving the precision pointing capability of current and next-generation airborne turreted forward looking infrared (FLIR) systems. Design an innovative method of improving the baseline geo-positioning accuracy of turreted and other electro-optic sensors.

DESCRIPTION: Currently, most military turreted electro-optic/infrared (EO/IR) sensor systems are commercial off-the-shelf (COTS) variants. These systems are designed to provide highly stable, long-range imagery of ground and maritime areas and targets. However, these systems have not been designed to provide highly accurate geo-location of these areas/targets. The capability to identify precise ground coordinates of high-value targets accurately will greatly improve the Navy’s capability for precision strike. The following areas should be addressed in this SBIR:

- Characterize the current absolute pointing error of representative EO/IR systems.
- Determine low-impact methods of improving geo-positioning accuracy and quantify potential improvement.
- Determine processing requirements for implementation on a Navy FLIR system.

PHASE I: Given current turreted EO/IR systems on aircraft, develop innovative techniques to improve absolute pointing accuracy possible over the existing system (for a system with inertial measurement unit (IMU) on one turret and one without).

PHASE II: Implement candidate techniques in software and demonstrate performance. Using government-furnished information (GFI) sensor and aircraft data, demonstrate performance of the algorithms non-real-time. Provide real-time implementation analysis (memory, processing, I/O requirements).

PHASE III: Transition the algorithm suite to a sensor platform to demonstrate performance.

PHASE III DUAL USE APPLICATIONS: This capability will aid counter drug efforts by non-military agencies by providing accurate geo-location data from airborne EO/IR sensors.

REFERENCES:
1. Kayton, M. and W. Fried, Avionics Navigation Systems 2nd Ed, John Wiley & Sons, New York, 1997.
2. Tieereon, D. and J. Weston, Strapdown Inertial Navigation Technology, Peter Perefrinus Ltd. On behalf of the Institution of Electrical Engineers, London, 1997.

KEYWORDS: Forward Looking Infrared (FLIR), EO/IR Sensor, Geo-Positioning, Precision Targeting, Precision Strike Targeting (PST), Turreted Sensors

N02-165 **TITLE:** Lightweight Ablating Insulation for Ramjet Combustion Chambers

TECHNOLOGY AREAS: Materials/Processes

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: PMA 208 - Aerial Target Systems

OBJECTIVE: Identify innovative, low-cost materials to be used as ramjet combustor insulators.

DESCRIPTION: Currently the insulation of choice is Dow Corning 93-104. The U.S. Navy needs innovative materials that could provide a lighter weight and higher performance insulator (thermal diffusivity, conductivity, and ablative performance). This material must form a rigid char that withstands typical shear forces found in the combustor flow field during combustion and without degrading the energy produced in the combustion chamber. Other requirements include enhanced bondability and minimized offgassing at the case bondline. Temperatures in the combustion chamber typically reach 2,200+^{o}F. Aircraft using these ramjets are designed for single flights and operate for several minutes

PHASE I: Determine the feasibility of new, innovative materials for use as a ramjet combustor insulator. Characterize the proposed insulator(s) performance, along with bench tests and laboratory characterization that demonstrates the performance objectives listed above.

PHASE II: Execute a limited production run of the insulator material for engines, designing to the U.S. Navy's ramjet contractor drawing for a combustion chamber insulator. Perform ramjet combustor rig testing to demonstrate that the insulator meets performance requirements. It is also desirable to characterize the visual signature of the insulation byproducts in this environment. Note: The combustor insulator needs to be able to be spin-cast, and/or pump-cast around a mandrel. The combustor is a cylindrical shape approximately 14 inches in diameter, 42 inches in length, and no more than 0.04 inches thick.

PHASE III: Provide production-representative insulated ramjet motor cases and conduct demonstration ground testing at conditions simulating a flight environment.

PHASE III DUAL USE APPLICATIONS: High-performance insulators have numerous uses in commercial combustion systems from boilers to incinerators. Higher temperature operation results in higher energy efficiency.

REFERENCES:
1. Drawing, Combustor Insulation: Generic Ramjet Combuster; available on the SBIR Interactive Topic Information System (SITIS) at http://dtica.dtic.mil/sbir/index.html

KEYWORDS: Ramjet, Insulator, Ablative, Combustor, Thermal Diffusivity, Testing

N02-166 **TITLE:** Rule-Based Information System for Training Resource Planning and Fleet Readiness Assessments

TECHNOLOGY AREAS: Human Systems

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: PMA 205 - Aviation Training Systems

OBJECTIVE: Enhance Fleet readiness by producing a rule-based model that represents the logical constraints and performance parameters affected by malfunctioning and out-of-configuration training equipment.

DESCRIPTION: The Armed Services must effectively train their personnel to perform maintenance functions in order to keep their weapon systems operating at an acceptable level. Training of this sort often depends upon the availability of specially engineered maintenance training devices and other training tools that simulate the behavior of malfunctioning weapon systems. Sometimes there are insufficient quantities of such training equipment, the maintenance training equipment itself is malfunctioning, or the equipment needs configuration updates to match the operational equipment it is supposed to represent. In all these cases, the training equipment may be inadequate or unavailable when maintenance training courses are taught, thus having an impact on Fleet readiness when the trainees are sent back to their units to perform their maintenance duties.

The Navy has no analytical model to quantify the impact that unavailable maintenance training equipment has on Fleet readiness. Such a model, if implemented in user-friendly software, would be invaluable in weighing management alternatives for the funding of maintenance trainer repairs, updates, and purchases.

PHASE I: Establish the feasibility of developing analytical tool and techniques capable of determining the impact that out-of-configuration and/or malfunctioning maintenance trainers and other training tools have on Fleet readiness. Identify and operationally define variables related to training equipment availability and affecting Fleet readiness. This development must consider and be closely coordinated with existing Navy training simulation models. Demonstrate the methodology and tools that will be used to show the impact of maintenance training equipment configuration and repair status on readiness via training.

PHASE II: Design, demonstrate, and evaluate the prototype rule-based model following the plan developed under Phase I. From the results of this evaluation, provide a preliminary analysis of Navy maintenance trainer configuration and repair status related to readiness via training.

PHASE III: Enhance the model developed under Phase II, populate the database with information representing the Navy's entire inventory of maintenance training equipment and tools, and install the resulting database on a Navy or DOD server(s). Determine the effectiveness of the database software and revise as necessary.

PHASE III DUAL USE APPLICATIONS: Telephone companies and the airlines took the lead in developing computer models of their organizations' operations to evaluate the potential profitability of installing or upgrading capital equipment. Other companies have developed computer models of profitability for planning purposes, and such models could be applicable to any organization that must decide on business alternatives. Nowhere, however, have we found reports of such models relating to commercial training equipment. However, businesses that have large amounts of equipment and service personnel in the field face similar training equipment problems to the Navy's, and similar models would be applicable to their training resource planning as well.

KEYWORDS: Configuration Management, Readiness Models, Training Effectiveness, Equipment Configuration, Maintenance Training, Fleet Readiness

N02-167 **TITLE:** Intelligent Embedded Diagnostic System for Future Avionic Systems

TECHNOLOGY AREAS: Information Systems

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT ID: PMA 276 - Light/Attack Helo Program

OBJECTIVE: Develop the next generation of intelligent diagnostic reasoners for future avionic systems, to include monitoring and analyzing on-aircraft components and transferring test data to off-system test equipment.

DESCRIPTION: Future maintenance strategies are expected to rely heavily on embedded diagnostics that will ensure the health of high-value avionic and electronic systems during real-time operations. Monitoring systems are required to sense and characterize operating performance levels (health of system) and predict system, subsystem, and component degradation levels (prognostics) in real time. Architecture is needed for standardization of information exchange between embedded diagnostic systems and automated test systems (ATS) and different maintenance levels, where necessary.

PHASE I: Demonstrate the feasibility of a real-time monitoring system to measure the status and health of avionic system components, categorize component failures, and predict remaining life-cycle. Characterize algorithms to model electronic components and circuitry performance characteristics. Analyze optimum performance, failure modes, and life-cycle. Determine what embedded diagnostic information from avionic systems should be available to ATS, and how this information should be transferred to and used by ATS.

PHASE II: Develop an open system diagnostic methodology, embedded software components, real-time diagnostic components, and development environment for an embedded diagnostic system. Demonstrate and validate diagnostic functionality, and demonstrate component reuse potential and information exchange, especially related to ATS. A modular architecture will be required to facilitate reuse of software modules and provide a basis for diagnostic component-based assembly. The implementation architectures must also address open interfaces and use of defined standards and data exchange formats referenced in the DoD Joint Technical Architecture. Further research is also needed to optimize embedded databases, emerging diagnostic expert systems, and advanced diagnostic modeling methodologies.

PHASE III: Package the diagnostic software components into distribution format. Perform a full-scale product demonstration on a selected avionic module or electronic system on a commercial or DoD ATS.

PHASE III DUAL USE APPLICATIONS: The proposed work will serve as a technology conduit for diagnostic architectures, diagnostic component modules, and diagnostic/prognostic research. This advanced diagnostic system is applicable to embedded diagnostics for commercial airline systems, space vehicle systems, commercial electronic systems, health monitoring, and expert diagnostics for advanced test system applications. This research, if successful, will revolutionize the development of embedded diagnostic systems.

REFERENCES:

1. DoD ATS Executive Agent Office, "Open Systems Approach Integrated Diagnostic Demonstration," Final Report, Jan. 1999.
2. "DoD Joint Technical Architecture (JTA) Version
3. Defense Information Systems Agency Center for Standards, 31 Mar 2000.
4. IEEE Std 1232.1-1997. "Trial Use Standard for Artificial Intelligence Exchange and Service Tie to All Test Environments (AI-ESTATE): Data and Knowledge Specification"
5. IEEE Std 1232.2-1998. "Trial Use Standard for Artificial Intelligence Exchange and Service Tie to All Test Environments (AI-ESTATE): Service Specification"
6. Brian K. Jones, Electronics for Experimentation and Research, Prentice-Hall International, 1986

KEYWORDS: Embedded Diagnostics; Artificial Intelligence; Diagnostic Reasoner; Prognostics; Condition-Based Maintenance; Automatic Test Equipment

N02-168 **TITLE**: High-Temperature (HT) Coatings for Turbine Blades and Vanes

TECHNOLOGY AREAS: Materials/Processes

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT IC: PMA 299 – Multi-Mission Helicopters Program Office

OBJECTIVE: Develop a high-temperature protective coating system that increases the hot-section components lives, time "on-wing," flight safety, and affordable readiness for naval aviation gas turbine engines.

DESCRIPTION: Military and commercial gas turbine engines used for aircraft, ships, and utility power generation require more durable and more reliable hot-section components in order to achieve their "designed for" life. Less durable parts lead to increases in unscheduled (and costly) inspections, engine repairs, and major engine overhauls. For aircraft applications, this equates to less time "on-wing," a severe reduction in flight safety, and a significant reduction in operational readiness. Aircraft that are affected include the AV-8B with the F402 engine and the H-60 helicopter with T700 engines. Advanced turbine engines currently in development, such as the F414 (F-18E/F) and the F119 and F120 (F-22 and the Joint Strike Fighter (JSF)), require much higher levels of turbine inlet temperatures, and hence much hotter hot-section components, to achieve robust engine performance and enable short takeoff/vertical landing (STOVL) operations.

PHASE I: Identify HT coating performance requirements and specifications for turbine engines. Define application techniques and characterize the coating system's composition and assess potential coating candidates. Select one or more coatings for further development in Phase II.

PHASE II: Coat several coupons and conduct laboratory hot gas and cascade testing of experimental coating systems and compare the results to baseline non-coated coupons. Based on the success of the most promising HT coating, coat engine hot-section hardware/components for assessment of gas testing under realistic operational conditions to confirm component service life improvements. (The government will provide the hot-section hardware). Determine the return on investment of the HT coated parts versus non-coated parts. Identify the coating and coating process for final development in Phase III.

PHASE III: If engine assets and test situations are available, provide coated blades for insertion into a Navy accelerated simulated mission endurance test (ASMET) to determine the coating system performance in an integrated engine under realistic operational conditions. Transition and implementation into naval gas turbine engines is the ultimate goal.

PHASE III DUAL USE APPLICATIONS: HT coatings can be used for a wide variety of components in industrial gas turbine engines and commercial aircraft engines, with applications in automotive and ship propulsion.

REFERENCES:

1. Ultra-Efficient Engine Technology Program Technical Accomplishment; Advanced Thermal Barrier Coating (TBC) Composite Selected for Increasing Temperature Capability of Turbine Airfoil System; Robert Miller; September 2000, http://www.ueet.nasa.gov/images/Milestones/4.0.pdf

KEYWORDS: Gas Turbines, High-Temperature (HT) Coatings, Thermal Erosion, Coating Processes, Engine Durability, Life-Cycle Cost

N02-169 **TITLE**: Innovative Gas Turbine Engine Propulsion

TECHNOLOGY AREAS: Air Platform

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: Air 1.0 – Program Management Acquisition/Operations

OBJECTIVE: Develop and demonstrate innovative gas turbine engine component technologies that have application to Navy engines with goals of increased power-to-weight ratio, reduced fuel consumption, increased life, improved maintainability, and improved affordability.

DESCRIPTION: New engine component technologies are sought to enhance the goals of the Integrated High-Performance Turbine Engine (IHPTET) program and the planned follow-on program called the Versatile Affordable Advanced Turbine Engine (VAATE) programs. These are integrated DoD/NASA/DARPA/industry programs structured to double propulsion capability. Specific technology development areas are sought to increase aero thermodynamic design capability for improved component efficiency levels, control of heat transfer, development of higher temperature and lower density materials; and develop innovative structural concepts. These developments must be compatible with affordable manufacturing processes. The VAATE program, structured around three focus areas, emphasizes specific themes important to achieving the affordability goal. The first area, the Durability Focus Area, will proactively develop, design, and test protocols to prevent component failure, increase life, enhance reparability, and ultimately improve performance. The second area, the Versatile Core Focus Area, will develop technologies for a multi-use, 4000-hour, maintenance-friendly engine core (compressor, combustor, and turbine). The third area, the Intelligent Engine Focus Area, will develop and integrate technologies that provide durable, adaptive, damage-tolerant engine health and life management features. Engine/airframe integration technologies are key in attaining the significant cost and weight reductions required to achieve the VAATE tenfold goal. Researchers will integrate aircraft thermal management, power generation, and flight control functions (via thrust vectoring nozzles) into the engine. The VAATE program, specifically the Intelligent Engine Focus Area, will evolve engines into integrated propulsion and power systems.

PHASE I: Define a viable innovative technologies that has application to future Navy gas turbine engines and/or components and has potential for integration into the IHPTET/VAATE engine. Technologies must be integrated within the engine contractors' approved advanced turbo propulsion plan (ATPP). Define the approach and substantiate the feasibility of the concept in the application. Define the benefits associated with meeting IHPTET phase III goals and VAATE I goals (See web page for description of VAATE and their associated goal sets for intelligent engine, versatile core or durability demo engine.

PHASE II: Refine and develop the concept/component through analysis and testing to validate the technology for its intended environment. Determine the requirements for and integrate the concept/component into an advanced Navy gas turbine engine system for IHPTET or VAATE demonstration. (This may be demonstrated by the inclusion of the technology into the IHPTET/VAATE engine contractor's ATPP.) Design and fabricate the concept/component for demonstration in an IHPTET/VAATE engine. Validate the benefits associated with the concept and quantify contributions to meeting IHPTET/VAATE goal sets.

PHASE III: Integrate the concept/component into a military application. Once the design space, potential, and operating constraints have been quantified in Phase II, the concept/component may readily be integrated into legacy and pipeline systems.

PHASE III DUAL USE APPLICATIONS: Aircraft gas turbine technology is vital to the U.S. industrial base. Because aircraft gas turbine technology is generally applicable to both military and commercial engines, achieving the IHPTET/VAATE goals can ensure continued U.S. preeminence in the increasingly competitive international turbine engine marketplace well into the 21st century.

REFERENCES:
IHPTET Related:
1. http://ppe.navair.navy.mil/
2. http://www.pr.wpafb.af.mil/divisions/prt/ihptet/ihptet.html
VAATE Related:
1. http://www.afrlhorizons.com/Briefs/Dec01/PR0105.html
2. http://www.asme.org/gric/2001/workshop/piscopo.pdf
3. http://www.fetc.doe.gov/publications/proceedings/99/99ats/3-4.pdf

KEYWORDS: Advanced Propulsion, Integrated High Performance Turbine Engine Technology (IHPTET), Versatile Affordable Advanced Turbine Engine (VAATE), Advanced Technology, Gas Turbine Engines, VAATE Cost to Capability Index (CCI), Prognostics and Engine Health Monitoring (PHM)

N02-170 **TITLE**: Injecting Reactive Materials into Targets in Conjunction with Shaped Charge Warheads

TECHNOLOGY AREAS: Weapons

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: PMA 242 - Defense Suppression Systems

OBJECTIVE: Develop and fabricate a device to effect entrapment of reactive materials in shaped charge jets.

DESCRIPTION: In recent years, several advanced liner material candidates with high heat of combustion have been tested with some promising results. Although the reactive shaped charge warheads can increase target kill by incendiary and thermal effects, they can also lack penetration performance due to the liner's material lower density against heavier targets. In addition, such advanced liner materials are deficient in ductility, are of low cost, and, in some cases, there are incompatibilities among different materials.

PHASE I: Develop a conceptual design for a device (passive or active) that enables a shaped charge jet to entrap or take on reactive materials prior to or, if necessary, during the target impact. Examine two configurations: conical and explosively formed projectile liners. Include strategy to record experimentally actual events of carrying the materials of interest into the interior of targets of interest. Conduct a feasibility investigation of integrating this device into an ordnance configuration similar to that of the Hellfire or M42 grenade.

PHASE II: Develop optimized detailed designs for the Phase I devices and fabricate units suitable for concept testing. Establish baselines. Conduct penetration performance testing against appropriate rolled homogeneous armor (RHA) plate/confined volume targets. Data should include, but not be limited to, pressure rise and thermal effects. Demonstrate the shaped charge's capability to carry materials of interest into the target. Provide test unit samples for evaluation testing against targets.

PHASE III: Transition the device into a risk reduction project resulting in a mature design suitable for a new missile program.

PHASE III DUAL USE APPLICATIONS: Potential commercial uses are mining, oil-drilling, foundry, work and demolition. Technology can be used to entrap choice of materials as catalysts or inhibitors to enhance the desired result. Such technology could be used for materials designed to inhibit reaction or contamination in tapping foundry crucibles with molten metal charges. This technology could also accommodate petroleum industries in enhancing oil recovery from deep drilling pipe perforation. In some respects, demolition could become safer if inhibiting materials were used in regions associated with fire hazards.

REFERENCES:
1. Walters, W. P. and Zukas, J. A., "Fundamentals of Shaped Charges", Wiley, New York, 1989.

KEYWORDS: Shaped Charge, Reactive Material, Metal Matrix Composites, Intermetallic Reactions, Coruscatives, Self-Propagating High-Temperature Synthesis (SHS)

N02-171 **TITLE:** Advanced Aviation Spatial Disorientation Trainer

TECHNOLOGY AREAS: Human Systems

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: PMA 205 – Aviation Training Systems

OBJECTIVE: Develop an advanced aviation spatial disorientation trainer that would train aviation personnel to recognize, avoid, and recover from various types of spatial disorientation.

DESCRIPTION: Each year, the Navy loses more than $100 million in downed aircraft and approximately 10 aircrew to spatial disorientation and motion sickness related accidents. Because of this insidious hazard, the Navy, Air Force, Army, Marine Corps, and Coast Guard must train their aviation personnel to recognize various types of spatial disorientation. Currently, this training is accomplished by using training devices as simple as Barany chairs and as complex as computerized rotation platforms. The Navy's only multi-station disorientation device (MSDD) was built over 20 years ago. Since then, simulation and training technology has advanced exponentially. An advanced training system is sought that will train recognition, avoidance, and recovery from spatial disorientation and motion sickness.

PHASE I: Develop plans for a spatial disorientation trainer based on the past 20 years of mishap data and analysis using the latest technology. Mishap data/analysis should identify the specific sensory and cognitive phenomena causing aviation mishaps. Determine the feasibility of the design to provide spatial disorientation training in a Navy training environment.

PHASE II: Further develop and refine the trainer based on Phase I results, and build a prototype to demonstrate effectiveness in a Navy training environment. From the results of this evaluation, provide recommendations for potential improvements to enhance device training effectiveness.

PHASE III: Enhance the prototype developed/acquired in Phase II, and install it at a previously designated aviation survival training center.

PHASE III DUAL USE APPLICATIONS: There are many commercial training applications for an advanced spatial disorientation training system. The Federal Aviation Administration (FAA), commercial airlines, and private flight training institutions are just a few non-military entities that require this type of training and would benefit from the research conducted.

REFERENCES:

1. Moroze, M.L. and Snow, M.P. (1999), "Causes and Remedies of Controlled Flight into Terrain (CFIT) in Military and Civil Aviation," 10th International Aviation Psychology Symposium (pp. in press), Columbus, OH: Ohio State University. This paper was cleared by ASC99-076 and SAFYPAS 99-0344 on 15 April 1999.
2. Braithwaite, M.G., Douglass, P.K., Durnford, S.J., and Lucas, G., "The Hazard of Spatial Disorientation during Helicopter Flight Using Night Vision Devices," Aviat Space Environ Med 1998, November 1969(11), pp. 1038-44
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5. Cheung, B., Money, K., Wright, H., and Bateman, W., "Spatial Disorientation Implicated Accidents in Canadian Forces, 1982-1992," Aviat Space Environ Med 1995, June 1966(6), pp. 579-85
6. Navathe, P.D. and Singh, B., "Prevalence of Spatial Disorientation in Indian Air Force Aircrew," Aviat Space Environ Med 1994, December 1965(12), pp. 1082-5
7. Bellenkes, A., Bason, R., and Yacavone, D.W., "Spatial Disorientation in Naval Aviation Mishaps: A Review of Class A Incidents from 1980 through 1989," Aviat Space Environ Med 1992, February 1963(2), pp. 128-31

KEYWORDS: Situational Awareness, Spatial Disorientation Training, Simulation, Aviation, Airline, Motion Sickness

N02-172 **TITLE:** Airborne Detection of Disturbed Soil Using Electro-Optic (EO), Hyperspectral, Infrared (IR), and Synthetic Aperture Radar (SAR) Sensors

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT II: PMA 290 - Maritime Surveillance Aircraft (MSA) Leadership Program

OBJECTIVE: Develop innovative technology capable of detecting soil disturbances using EO, IR, and SAR airborne sensors.

DESCRIPTION: The ability to detect land mines and characterize soil disturbances, indicative of heavy equipment and troop movement, remotely (from the air) is of high interest to homeland defense, mine countermeasures and the DOD Counter Drug Office. Design innovative processing algorithms to detect areas of disturbed soils automatically. Soils that have recently been disturbed may show the following characteristics:

- Different densities that may cause the thermal characteristics to change (detect with IR)
- Mixing different soil types may show in the visible spectrum as different colors (visible hyperspectral)
- Different soil densities (SAR)

PHASE I: Using existing imagery databases of visible, IR, and SAR data, demonstrate the feasibility of automatically detecting soil disturbances.

PHASE II: Determine the combination of sensors and algorithms that will optimize detection under a variety of expected environmental conditions. Determine receiver operating characteristics (ROC) curves for background and target conditions of interest.

PHASE III: Transition the algorithm suite to a sensor platform(s) to demonstrate performance.

PHASE III DUAL USE APPLICATIONS: Mine detection, heavy equipment movement, counter drug, and counter terrorism.

REFERENCES:

1. DePersia, A., A. Bowman, P. Lucey, and E. Winter, "Phenomenology Considerations for Hyperspectral Mine Detection," Proceedings SPIE 2496, 1995, pp. 159-167.
2. Salisbury, J., L. Walter, N. Vergo, and D. D'Aria, Infrared (2.1 - 25mm) Spectra of Minerals, Johns Hopkins University Press, Baltimore, 1991.

KEYWORDS: Airborne Mine Detection, Surveillance, Reconnaissance, Close Air Support, Littoral Mine Countermeasures (MCM), Soil Disturbances

N02-173 **TITLE:** Human Centered Performance Assessment Tools

TECHNOLOGY AREAS: Human Systems

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT I: Joint Strike Fighter

OBJECTIVE: Develop software tools for creating and analyzing measures of team performance/effectiveness captured from training events.

DESCRIPTION: Team performance assessment can be used to reveal strengths and weaknesses of training approaches. A system is required that captures relevant aspects of team performance including team processes, team-related cognition, and behavioral components focusing on team processes such as information exchange, initiative, and decision making. It also must address team member cognitive components such as shared mental models that tactical team members rely on to coordinate in the absence of explicit communications (Entin et al., 1999). Intelligent team performance diagnosis would allow for the development of team-specific skills. New team members could be more quickly and easily assimilated into an incumbent team.

PHASE I: Determine the feasibility of developing an expert diagnostician tool that will automatically synthesize team performance information and generate prescriptive feedback for the team. The proposed tools should enable online intelligent diagnosis of individual and team performance. They should demonstrate a process for mapping team competencies to training objectives and events, as well as to performance measures, and identify component technologies with which interface might be required (i.e., existing performance measurement data and databases, automated data collection tools, models of expertise, instructional or training management databases, handheld or PC-based instructor tools, existing simulation command, control, communications, computers, intelligence, surveillance, and reconnaissance (C4ISR) data and databases).

PHASE II: Develop components for the expert diagnostician tool. Develop a prototype that will be used to demonstrate the tool's ability to collect key team performance data, interface with critical technologies, reduce/integrate/analyze data to provide diagnostic profiles of individual and team performance, and support customizable debriefs. Success will be measured by a comparison of traditional performance assessment techniques with output of the new tool, which should generate more reliable, valid, and diagnostic measures, as well as effective prescriptive feedback that is automatically and rapidly generated and provided to the user. It will also be measured through demonstrations of the system's reliability, operability, and maintainability.

PHASE III: Transition software tools into the joint Service training environment. Perform additional usability and validation tests at the joint Service level and implement the identified refinements.

PHASE III DUAL USE APPLICATIONS: All commercial simulation-based training environments could benefit from real-time performance measurement, diagnosis, and feedback.

REFERENCES:
1. Entin, E.E. & Serfaty, D., "Adaptive Team Coordination." Human Factors, 41 (2), pp. 312-325, 1999

KEYWORDS: Team Training, Performance Measures, Performance Assessment, Expert Performance Modeling, Automated Intelligent Diagnosis, Training System Design

N02-174 **TITLE:** Advanced Low-Drag Ram Air Turbine

TECHNOLOGY AREAS: Air Platform

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: PMA 234 - A-6/EA-6 Program

OBJECTIVE: Develop a new advanced low-drag ram air turbine (LD-RAT) that uses an internally bladed turbine (i.e., similar to gas turbine engine) that has the capability to provide emergency and primary power with greatly reduced drag, both in operating and non-operating modes.

DESCRIPTION: RATs provide emergency electrical and/or hydraulic power for military and civilian aircraft. In addition, RATs provide primary electrical and/or hydraulic power for military airborne stores such as electronic warfare jamming pods and refueling stores. RATs traditionally consist of a bladed (i.e., propeller) turbine connected to a power source, either an electrical generator or a hydraulic pump. Since these power sources typically require a fixed rotational speed to function properly, RATs usually incorporate complex blade pitch control mechanisms to maintain a fixed rotational speed under varying airspeed/airflow conditions. In instances where they provide primary power for airborne stores, the complexity of present RATs leads to poor reliability, availability, and maintainability (RAM) and high ownership costs. Unfortunately, this technology is currently used on the AN/ALQ-99 tactical jamming pod on the EA-6B Prowler aircraft but needs to be revitalized for the replacement aircraft in the 2010 time frame.

The LD-RAT must be capable of operating both in the subsonic and supersonic flight regimes, with significant decreases in drag, and offer improved RAM and reduced ownership costs. The LD-RAT should have the capability of meeting these requirements in both external and internal installations. The demonstration of LD-RAT technology must have the potential to generate 40 kW of continuous 115 VAC, three-phase, 400 Hz power while operating within both the current and potential performance envelopes for the AN/ALQ-99 tactical jamming pod.

PHASE I: Research and develop analytical models of LD-RAT, determining feasibility and technical merit. Analyze and correlate, with smaller scale model wind tunnel results, the basic performance that could be generated in a full-scale LD-RAT.

PHASE II: Conduct preliminary design and supporting analysis for a full-scale LD-RAT for the AN/ALQ-99 pod on the EA-6B aircraft. Assess improvements in drag, RAM, and ownership costs. Fabricate and test prototypes of key components (i.e., turbine stator, etc.) of a full-scale LD-RAT. Perform critical and final design of the LD-RAT, including computational fluid dynamics and structural analysis, for the AN/ALQ-99 pod for the EA-6B aircraft. Build and demonstrate a prototype LD-RAT capable of being mounted and operated on the present AN/ALQ-99 pod within its present performance envelope.

PHASE III: Perform test and evaluation of prototype and investigate adaptation of the LD-RAT for other military and civilian applications. These applications include an AN/ALQ-99 pod LD-RAT capable of operation on other Navy tactical aircraft, emergency RAT applications for manned and unmanned, tactical and non-tactical, and military and civilian aircraft.

PHASE III DUAL USE APPLICATIONS: Commercial uses of the LD-RAT may exist for small civilian aircraft, serving as emergency electrical/hydraulic power. If a commercial market for unmanned aircraft evolves in the future, the LD-RAT has applications both for emergency electrical/hydraulic power as well as supplemental power for payloads.

REFERENCES:
1. AN/ALQ-99 Tactical Jamming System (TJS); http://www.fas.org/man/dod-101/sys/ac/equip/an-alq-99.htm

KEYWORDS: Low-Drag Ram Air Turbine, Advanced Technology, Aircraft Electrical Power, Aircraft Hydraulic Power, Ram Air Turbines, Drag

N02-175 **TITLE:** Advanced Models to Provide Improved Diagnostic, Prognostic, and Health Management (PHM) Capabilities Across Interconnected Aircraft Subsystems

TECHNOLOGY AREAS: Air Platform

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT I: Joint Strike Fighter

OBJECTIVE: Develop and demonstrate advanced models to provide diagnostic PHM capabilities across interconnected aircraft systems.

DESCRIPTION: Diagnostic PHM capabilities are being developed and implemented for various aircraft systems. While significant diagnostic and prognostic capabilities are provided for the specific subsystem of interest; interrelationships among interconnected subsystems from a diagnostic and/or prognostic perspective are less understood. With embedded area reasoners present to fuse together information from different aircraft subsystems, it is possible to consider diagnostic and prognostic interrelationships among interconnected subsystems. With this in mind, this SBIR is devoted to developing and demonstrating advanced models to define these cross-subsystem relationships from a diagnostic PHM perspective. For example, a model capable of determining the impact of incipient fault or minor failure conditions of a major subsystem, like the engine, on interconnected subsystems like electrical power or drive systems (secondary damage or prematurely degrading).

PHASE I: Select one subsystem of an aircraft, such as an engine. Determine the general effects of the failure of that subsystem and relate it to the health and performance of other interrelated subsystems. Prioritize the failures by their overarching effects and their detriment to the air vehicle. Lay out a top-level architecture for software tools and models that will attempt to define these interconnected faults, failures, and secondary damage effects across the air vehicle. Develop and demonstrate models for simple diagnostic and prognostic relationships.

PHASE II: Define and develop the software architecture, tools, and models in greater detail and across other interconnected aircraft subsystem. Integrate these tools and advanced models, for diagnostic PHM across the interconnected subsystems, into a complete software module that will operate as part of a larger comprehensive onboard and offboard PHM system. Conduct complete and comprehensive demonstrations across all interconnected subsystems. Assess diagnostic PHM effectiveness and model performance.

PHASE III: Develop, validate, and deliver a complete set of modeling programs and techniques to be used on aircraft systems. Integrate these capabilities with a comprehensive PHM system. Apply these modeling programs to a new aircraft development program like the Joint Strike Fighter (JSF).

PHASE III DUAL USE APPLICATIONS: This tool can be used for any type of PHM system in use. Any platform from a fighter airplane to a navy ship to a commercial aircraft is a candidate for this technology.

REFERENCES:

1. SAE E-32 Committee Documents
2. ISO TC/SG5 Draft Standards
3. IEEE Aerospace Conference Proceedings for 2001 and 2002 Track 11 PHM

KEYWORDS: Prognostics and Health Management, Software Tool, Effects of Loss of Capability, Diagnostic, Aircraft Subsystem, Turbine Engine

N02-176 **TITLE:** Surface-Mounted, Non-Penetrating Survivable Attachment Device

TECHNOLOGY AREAS: Materials/Processes

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT IC: PMA 275 V-22 (Osprey) Program

OBJECTIVE: Design and develop an innovative, low-cost, easy-to-apply device to rigidly restrain and attach cables, fuel lines, and hydraulic lines to the aircraft without altering the structure.

DESCRIPTION: In modern aircraft, cables, wiring harnesses, hydraulic lines, and fuel lines are routed throughout the airframe. It is useful to install these systems after the aircraft has been partially or fully assembled without altering the structural integrity of members to which they will be attached. Therefore, it is not appropriate to alter the structure by drilling fastener holes, which cause stress concentrations, for the purpose of installing bolts and screws through existing structures. Currently, “bonded studs” are used to attach and restrain such systems. These studs consist of a fastener with a widened head that acts as a base, which is bonded to the structure using adhesives. While this method of attachment supports in-plane shear stress, it does not perform well under out-of-plane loading (peel stresses), installation misalignment, accidental impact, and dynamic or shock loads. Failure of these studs has resulted in considerable maintenance costs and a decrement to readiness. An alternative attachment system needs to be developed that better tolerates installation misalignment and mislocation by offering adjustment features, is more survivable to accidental abuse and shock loads, better resists out-of-plane and dynamic loads, and is relatively easy and quick to install on existing structural details like flanges without compromising structural integrity. The proposed solution should also ensure that multi-directional in-service static, fatigue, and shock loads and preloads are sufficiently well reacted to avoid failure of the attaching structure or substrate and the attachment device.

PHASE I: Address various critical problematic attachment areas on current Navy aircraft like the V-22, and define, develop and demonstrate a multi-location attachment device concept applicable to fixed- and rotary-wing aircraft.

PHASE II: Refine the innovative design of the attachment system and evaluate its performance for various critical and problematic applications. Strength and durability comparisons should be made with existing “bonded-stud” properties.

PHASE III: Transition the qualified device to the V-22 and other fixed- and rotary-wing aircraft.

PHASE III DUAL USE APPLICATIONS: A rapid, easy-to-install, survivable, post-assembly attachment device would have applications in many transportation and industrial areas.

REFERENCES:

1. Details of current attachment devise will be available on the SBIR Interactive Topic Information System (SITIS) at http://dtica.dtic.mil/sbir/index.html

KEYWORDS: Bonded Stud, Post-Assembly Attachment, Adjustable Attachment, Multi-Directional Loading; Improved Reliability, Maintainability and Availability (RMA); Structural Integrity

N02-177 **TITLE**: Gas Turbine Engine Emissions and Noise Modeling

TECHNOLOGY AREAS: Air Platform

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT I: Joint Strike Fighter

OBJECTIVE: Develop modeling tools that accurately predict gas turbine engine emissions and/or noise.

DESCRIPTION: The environmental impact of Navy and Marine Corps aircraft on the community and within the air district where the aircraft are based is of concern to base commanders and weapon system teams. Bases intended to receive the Joint Strike Fighter (JSF) aircraft are located in air districts at or near non-attainment of the national ambient air quality standard (NAAQS) for the emissions of ozone precursors and particulate matter. Community noise issues have led to instances of litigation against military bases. This issue is related primarily to noise propagation from in-flight aircraft and flight patterns in the vicinity of the base. Modeling of the emission and noise characteristic of aircraft gas turbine engines is needed to facilitate early evaluation of environmental impact and to enable analysis of technology and methods to reduce engine emissions and control noise. The emissions of concern are: oxides of nitrogen (NOx), unburned hydrocarbons [UHC, also known as volatile organic compounds (VOC)], carbon monoxide (CO), and particulate matter (PM) below 10 microns in diameter. The capability of current gas turbine combustor models to predict these emissions is usually limited by the number of steps used to simulate combustion.

PHASE I: Develop a model of basic/generic gas turbine engine emissions and/or noise production. The emission model may be based on the combustor component only. Identify pertinent parameters that have the greatest influence on emissions or noise while maintaining relevance to military aircraft gas turbine engines. Demonstrate the impact of a design or operational change on emissions or noise production.

PHASE II: Refine the model as necessary. Evaluate the accuracy of the model by comparing predictions to experimental data. Experimental data are to be obtained via sub-scale testing; therefore, prototype hardware must be fabricated and tested or access to experimental data otherwise obtained. Model design changes that reduce emissions or noise and verify that the model accurately predicts these reductions. Identify candidate technologies that will be evaluated at full scale.

PHASE III: Refine the model as necessary. Apply the model to a specific JSF engine or component. Evaluate the effectiveness of technology options in reducing emissions or noise using the model for this specific application. Develop champion solution(s) for application to the JSF engine, and model the impact of the candidate technology on JSF emissions/noise. Verify the capability of the model on a full-scale test.

PHASE III DUAL USE APPLICATIONS: Use of the analytical tools and solutions early in the design process will significantly reduce development costs of commercial aircraft engines. Commercial aircraft have long had emission and noise requirements.

REFERENCES:

1. Hamer. A.J. and Roby, R.J., "CFD Modeling of a Gas Turbine Combustor Using Reduced Chemical Kinetic Mechanisms," AIAA 97-3242, July, 1997.
2. Menon. S. et al., "Large Eddy Simulations of Combustion in Gas Turbine Combustors," AIAA Paper 2000-0960, January, 2000.
3. Birkby, P. et al., "CFD Analysis of a Complete Industrial Lean Premixed Gas Turbine Combustor," ASME 2000-GT-0131, May, 2000.
4. Cannon, Steven M., et al., "3D LES Modeling of Combustion Dynamics in Lean Premixed Combustors," ASME Paper, 2001-GT-0375, July, 2001.
5. Mahias, O. et al., "Lean Premixed Combustor Emissions Performance Modeling Using 3D CFD Codes," AIAA Paper July, 2000.
6. Tolpadi, Anil K., et al., "Soot Modeling in Gas Turbine Combustors," ASME Paper 97-GT-149, June, 1997.

KEYWORDS: Emissions, Noise, Modeling, Combustion, Exhaust Nozzle, Environmental

N02-178 **TITLE:** Next-Generation Air Deployable Active Receiver (ADAR)

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT II: PMA 264 - Air Anti-Submarine Warfare (AASW) Systems

OBJECTIVE: Design a low-frequency volumetric receiving array for use with the Extended Echo Ranging (EER) family.

DESCRIPTION: The EER family consists of a receiving sonobuoy (SSQ-101, Air Deployable Active Receiver (ADAR)) that is a low frequency horizontal receiving array with it's associated electronics and an active source sonobuoy (SSQ-110), which contains two explosive charges used as sound sources. Sonobuoys are classified by size (A, B, C, etc.) and type (active, passive or measurement). The SSQ-101 ADAR and SSQ-110 EER sonobuoys are A-size, expendable, non-repairable sonobuoys. The SSQ-101 does not provide enough array gain in important operational areas. An aircraft launched A–size standard sonobuoy design has the following characteristics: diameter of 4.875 in (+0/-.125 in); length of 36 in (+0.125/-0.188 in); maximum weight of 39 lbs. In metric units this would be: diameter of 123.825 mm (+0/-3.175 mm); length of 914.4 mm (+3.175/-4.775 mm); maximum weight of 17.7 kg.

A new volumetric array with a larger horizontal aperture is needed. Two to three times more aperture than the present design is needed. Vertical aperture is also desired. The new design can be larger than A-size, but should be as small as possible.

PHASE I: Paper study and conceptual design of a new array with two to three times more aperture at two specific frequencies within the ADAR sonobuoy's current frequency range.

PHASE II: Fabrication and test of two over-the-side models, one at each design frequency.

PHASE III: Development of air-deployed and ship-deployed array.

PHASE III DUAL USE APPLICATIONS: It is expected that the array could be used for tracking mammals and also by the Coast Guard for tracking drug smuggling.

REFERENCES:

1. Rick Fillhart and Don Russo, SSQ-101 Element Dimensions, NAVAIR, 11 January 2002 (to be made available on the SITIS web site).

KEYWORDS: ADAR, Volumetric, Array, Air-Deployed, Ship-Deployed, EER

N02-179 **TITLE:** Homeland Defense FAA/DoD Data Link Connectivity

TECHNOLOGY AREAS: Air Platform

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT ID: PMA 276 - Light/Attack Helo Program

OBJECTIVE: To develop a seamless command control capability between the FAA air traffic management system and DoD air defense assets. The new capability should take advantage of new and emerging digital networking technologies to provide a robust, autonomous, adaptive network. The capability will offer real time connectivity between FAA civil radar and DOD command and control authority to minimize the time required to prosecute airborne terrorist threats.

DESCRIPTION: A seamless networking capability between the FAA ground surveillance network and the DOD aircraft command infrastructure is proposed to provide a common operating picture of the civil airspace through sensor fusion. The network will provide the capability for fused information to be securely presented to military aircraft, appropriate civilian authorities and air traffic controllers. This will enhance homeland defense by cueing appropriate authorities to aircraft deviating from filed flight plans to allow appropriate actions to be taken in a timely manner including, potentially, external control of the aircraft. Security of the network will be a prime consideration if the capability for external control of the aircraft is considered. The FAA and DoD command and control networks use different standards, equipment and operating procedures. Developing a network that bridges these differences and can be integrated into the existing ground and aviation infrastructure poises a unique set of problems. The critical nature of Homeland Defense increases the complexity of the issue. This effort supports cooperative surveillance needs as defined by the Core Avionics Master Plan (CAMP) Cooperative Surveillance Roadmap for integration of forces and common operational picture leading to information dominance.

PHASE I: Recommend an appropriate solution for a FAA/DoD network, including information requirements/messages, and integration approach. Determine feasibility of proposed solution for digital connectivity between the FAA, the military command and control, and appropriate civilian authorities. Consideration should be given first to employing existing DoD and FAA network/data link physical layers and messaging standards. Develop a system architecture and design for a civil/military air-to-air and air-to-ground network, using emerging technologies, to create an autonomous, adaptive network that will provide seamless connectivity among the FAA, DoD and appropriate civilian authorities for Homeland Defense,

PHASE II: Develop prototype system and demonstrate the capability for the secure transfer of voice and/or data or both between an FAA controller and the DoD aircraft.

PHASE III: Fully develop system for integration into Naval aircraft and into Air Traffic Control.

PHASE III DUAL USE APPLICATIONS: Potential commercial applications include the secure transfer of voice and/or data or both for law enforcement applications, for shore to ship applications where ship movement information is considered to be of potential interest to terrorists (liquefied propane tankers, for example), and for the movement of corporate executives in areas of the world that have had a history of kidnapping.

REFERENCES:
1. Naval Aviation Core Avionics Master Plan

KEYWORDS: Data Link, FAA, Common Air Picture, Surveillance, Digital, Cockpit, Networks

N02-180 **TITLE:** Cosite Interference (Antenna Coupling) Management Technology for Airborne Communication Systems

TECHNOLOGY AREAS: Air Platform

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: PMA 231 - E-2/C-2 Leadership Council

OBJECTIVE: Provide an active integrated algorithm/system to minimize cosite interference on airborne platforms using multiple antennas and wide-band waveforms.

DESCRIPTION: Modern airborne command and control (C2) systems use multiple colocated radio frequency (RF) emitters/antennas for simultaneous operations (SIMOP) to provide effective RF communications. The potential exists, during SIMOP, for the RF emitters/antennas in close proximity to interfere with each other. Research is needed to develop a system that can actively manage cosite interference across the system during SIMOP to minimize negative cosite effects and improve communication system performance. Network centric warfare and the wide-band networking waveform will force more Naval aircraft to integrate many new antennas to an already antenna-crowded aircraft. This will increase the cosite interference problem. This supports the communications needs as defined by the Core Avionics Master Plan (CAMP) Communications Roadmap for Joint Tactical Radio System (JTRS) technology and efficient use of bandwidth.

PHASE I: Determine cosite interference management system approach

PHASE II: Develop a prototype system and demonstrate it in a target aircraft.

PHASE III: Develop a deliverable system for application to all Naval aviation platforms.

PHASE III DUAL USE APPLICATIONS: Some commercial products are available: multi-couplers, interference cancellation systems, and filter/power amplifiers. These systems are designed to minimize specific elements of cosite interference. New systems could be sold commercially, targeted at modern airborne platforms that have increasingly more complex communications requirements/systems and require SIMOP.

REFERENCES:
1. Joint Tactical Radio System (JTRS), http://www.jtis.saalt.army.mil
2. Naval Aviation Core Avionics Master Plan (CAMP)

KEYWORDS: Joint Tactical Radio System (JTRS), Cosite, Interference, Command and Control (C2), Antenna Coupling, RF Communications

N02-181 **TITLE:** Multi-Platform Undersea Warfare Modeling/Simulation Using Netcentric Techniques

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: PMA 264 - Air Anti-Submarine Warfare (AASW) Systems

OBJECTIVE: Develop a netcentric modeling and simulation tool set that can be used across such disparate and remote platforms as patrol aircraft, destroyers, frigates, submarines, satellites, unmanned aerial vehicles (UAVs), etc. in the naval Fleet. This new tool would provide faster than real-time, in-situ solutions in hostile littoral environments where computationally intensive models are required in order to assess the situation effectively and efficiently.

DESCRIPTION: Estimating environmental parameters and performance is critical to successful mission operation in today's rigorous defense industry. A new tool is necessary to provide an in-situ, faster than real-time acoustic modeling and environmental characterization capability to the Fleet and other Navy laboratories via secure wide area network (WAN) interfaces such as SIPRnet (secret internet protocol router network). This new tool will require an intuitive cross-platform operator interface for ease of use, and will need to be accessible via any standard web browser software. The software architecture and code must be designed for optimal and timely use of any new hardware architecture and vice versa. The new system should incorporate state-of-the-art database technology to ingest, format, and process large quantities of data that will be used by models and simulations, as well as provide identification of data quality. A method for providing more complex acoustic modeling assets to Navy personnel in the field will be required to keep pace with the data being collected and the complex environments in which the Navy will operate.

The modeling capabilities should include multiple acoustic models to choose from, such as ray-based, parabolic equation, and coupled-mode, as well as range-dependent and -independent models, newly developed inversion algorithms, and environmental databases. In order to use the correct acoustic model for the job, a modeling decision engine (MDE) must be developed to identify the "best-fit" list of models and present those options to the user. This concept of an "intelligent agent," which prevents erroneous use of the models and algorithms as well as the data, will assist in choosing appropriate tools and data. In addition to this, the MDE must ingest and invert, and handle all interfacing to remove time-consuming data entry and reduce operator error. Data may exist in various degrees of quality between multiple laboratories and systems across the acoustic community. Data mining would be required, as well as some analysis of data reliability.

PHASE I: Access the feasibility of various configurations of the netcentric system, which will use the latest technologies and methods. Develop initial alpha versions of the graphical user interface (GUI) and the MDE software as well as a small stand-alone conceptual version of the high-speed processing system.

PHASE II: Design and implement the entire architecture, where it will interface with the existing network. Provide a complete system demonstration of the netcentric capability of the facility. Develop the software (GUI and MDE) to a beta level.

PHASE III: Develop the fully functional unit to enable faster than real-time processing. The system will include error identification and recovery capability, as well as system maintenance software. Develop the software to a final operational version and implement. The systems will be implemented in multiple laboratories.

PHASE III DUAL USE APPLICATIONS: In addition to classified Navy programs, this technology can be used by other branches of the military, as well as other government agencies such as the CIA, FBI, NSA, Coast Guard, and drug interdiction units. Applications for unclassified versions include university research and other efforts needing access to high-speed, low-cost modeling and simulation. Other applications include seismic studies, oil exploration, search and recovery missions, commercial fishing, ocean monitoring, and others.

REFERENCES:

1. Paul C. Etter, Underwater Acoustic Modeling – Principles, Techniques, and Applications, Elsevier Applied Science, New York, 1991.
2. Robert J. Urick, Principles of Underwater Sound, McGraw Hill, New York, 1967.

KEYWORDS: Netcentric, Parallel Processing, Modeling, Simulation, Acoustic, Littoral Environments

N02-182 **TITLE**: Environmental Sensor Simulation System

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT II: PMA 264 - Air Anti-Submarine Warfare (AASW) Systems

OBJECTIVE: Develop a simulation environment that allows realistic testing and training for the next generation of environmental sensors.

DESCRIPTION: There is a need for a system that will provide a simulation environment for the next-generation environmental sensor that supports antisubmarine warfare (ASW). Such a system is needed to provide a system engineering design tool that allows end-to-end simulation of an oceanographic and meteorological sensor. In addition, it must provide a consistent simulation environment for a deployed ASW search sensor system. It will be used to identify the number of environmental sensors needed to characterize accurately the environment as well as the spatial and temporal sampling of the environment, and assist in development of new algorithms to process the data. System development engineers will use the system to change possible configurations of the environmental sensor, such as a new thermistor string attached to a sonobuoy. The environmental sensor simulation system will provide the environmental measurements (from a stored database) with realistic temporal and spatial fluctuations as if the simulated sensor were in the water. The specific environmental parameters are wind speed, temperature, salinity, sound speed, bottom depth, and bottom composition. The system should also allow for simulated acoustic search sensors working within the same environment along with target tracks so that the effectiveness of the new environmental sensor to support submarine prosecutions can be evaluated.

PHASE I: Provide architecture and methodologies for creating a virtual three-dimensional spatial cube of the ocean that evolves with time and results in realistic measurements (e.g., temperature, reverberation, ambient noise) for a simulated environmental sensor (e.g., temperature, salinity, etc.).

PHASE II: Provide technical demonstration of non-real-time simulation system for a specific ocean that allows the specification of different types of environmental sensors that returns realistic outputs from the specified sensors as if they were deployed in the ocean for a specified length of time. The outputs should be suitable for use with simulations of the environmental sensor processing and the outputs of the environmental processing into a decision aid that determines optimal acoustic search sensor placement and configuration. The system should also allow for placement of acoustic search sensors within the same ocean environment, along with simulated target tracks so that the effectiveness of environmental sensors to characterize the environment can be evaluated through the capability of a tactical decision aid (TDA) to place acoustic search sensors optimally.

PHASE III: The environmental sensor simulation environment should be tailored to support a smaller range of environmental sensors, but the environmental component of the sensor should be able to operate in real time. The environmental component will be integrated with the generic acoustic simulation system (GASS) environment for improved sensor development and training for new environmental sensors. Some or all components should be integrated into the tactical acoustic measurement and decision aid system (TAMDA).

PHASE III DUAL USE APPLICATIONS: This simulation environment would be useful for the system development, testing, and training of commercial environmental sensors. Companies building environmental sensors to monitor water quality, fish stocks, and sewage outflow could evaluate their existing and new sensors within this environment.

REFERENCES:
1. Flynn, D. F., "Tactical Acoustic Measurement and Decision Aid Environmental Sonobuoy Program," NAVAIR Report, 26 October 2000.

KEYWORDS: Environment, Simulation, Sensors, Acoustic, Decision Aid, Tactical Acoustic Measurement Sonobuoy

N02-183 **TITLE**: Tools and Technology for Automating Software Systems Integration

TECHNOLOGY AREAS: Information Systems

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT I: Joint Strike Fighter

OBJECTIVE: Develop tools and technology to preserve the enormous investments made in existing and new information systems.

DESCRIPTION: Most companies and government organizations have invested huge sums of money over many years in software systems needed to successfully operate their business. Most of the mission-critical systems are still functioning, but having been implemented over a number of years using different methodologies and technologies, they rarely talk or work well with each other. Tools and technology are needed to automate the integration of existing legacy and new software systems (i.e., operating systems and languages) and their respective hardware platforms. DoD's need to execute network-centric operations requires network-based systems to be developed from new object-oriented (OO) systems integrated with legacy systems. Industry also has a similar network-centric operations need. Once software and hardware systems are integrated and a common interface is developed between hardware and software components and systems, high-level functions supporting multi-contractor program status and oversight, complex analysis and reporting, acquisition boards, and collaborative heterogeneous information access can easily be developed. The joint strike fighter (JSF) air system will be comprised of both legacy and emerging technologies in both software and hardware.

PHASE I: Determine feasibility and develop the implementation requirements for automating the integration of software and hardware systems. Develop a recommendation for Phase II implementation.

PHASE II: Develop, test, document, and demonstrate initial integration capability specified in Phase I effort.

PHASE III: Following successful Phase II completion, work will be done to transition the product(s) to the JSF Air System baseline. This SBIR work can be implemented on various platforms in both industry and military. Therefore, funding could be leveraged from another service to share the cost. It may also be feasible to establish a dual-use agreement if industry can leverage from the product(s).

PHASE III DUAL USE APPLICATIONS: This technology has application to Internet-wide collaboration, medical information processing, logistics, data warehousing, project development, operations, and maintenance.

KEYWORDS: Collaboration, Data Islands, Information Integration, Object-Oriented (OO) Technologies, Network-Centric Operations, Legacy Systems Integration

N02-184 **TITLE**: Training Simulation Intelligent Scenario Generation Tools

TECHNOLOGY AREAS: Human Systems

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT IC: PMA 265 - F/A-18 Program

OBJECTIVE: Develop innovative software tools to automatically generate simulation training scenarios to meet syllabus requirements and training objectives.

DESCRIPTION: Given the complexity of modern, multi- or joint-service distributed simulation training events, the need for adaptive exercise management (i.e., developing, assessing, controlling, and reconfiguring large-scale scenario exercises) has become more acute. Intelligent scenario generation tools, such as collaborative software agents, that can facilitate the rapid reconfiguration of scenario events in a manner that is pedagogically grounded to support learning are sought. These tools will interface with training management databases to extract student historical data, develop scenarios to target the deficient mission-essential competencies and skills, and then interface with simulation control stations/instructor operator stations for scenario design-to-target student deficiencies. The tools should be versatile and adaptive to meet the training simulation needs of both individual students and teams operating in both local or distributed training environments.

PHASE I: Determine the feasibility of developing an expert diagnostician tool that will automatically generate simulation training scenarios and reconfigure scenario events to meet training objectives. Identify necessary linkages, interfaces, and transitions to existing and planned Navy (or joint service) programs and tools (e.g., existing performance measurement data or databases, automated data collection tools, models of expertise, instructional or training management databases, existing simulation C4ISR data and databases, etc.), and specify necessary functional properties of the proposed system.

PHASE II: Develop and design intelligent software processes to support automated management. Develop innovative software tools to search, provide suggestions, and reconfigure preplanned, archived, and new scenario events to support learning. Success should be measured by the extent to which the tool facilitates the design and modification of a scenario based on pedagogically sound learning principles, permits the rapid modification of existing scenario events, provides the capability to design new events or retrieve archived events, and results in performance improvements.

PHASE III: Transition software tools into the joint-service training environment. Perform additional usability and validation tests at the joint-service level, and implement refinements identified.

PHASE III DUAL USE APPLICATIONS: All commercial training environments requiring techniques for the generation of training scenarios.

KEYWORDS: Scenario Generation, Training Management, Distributed Training, Cognitive Task Analysis, Expert Diagnostician, Simulation Training

N02-185 **TITLE:** Universal Automated Flight Simulator Fidelity Test System

TECHNOLOGY AREAS: Human Systems

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT I: Joint Strike Fighter

OBJECTIVE: Develop a comprehensive and flexible set of software tools suitable for assessment, verification and validation testing of military flight simulators.

DESCRIPTION: In order to conduct valid air vehicle research, provide accurate flight test support, and train proper piloting skills in a flight simulator, high-fidelity simulation of aircraft flying qualities and performance is necessary. The simulation fidelity is determined primarily by direct comparison with aircraft flight test data. Manual execution of the necessary flight tests in a simulator is a lengthy process involving skilled test pilots and aerospace test engineers. Automated test drivers have been developed to supplement the manual techniques. Computer-controlled stick, pedal, and throttle inputs are used to exercise the flight and engine dynamics of the simulator and record the results. When implemented correctly, these automated fidelity test drivers have made the total debug and validation test process much more efficient and effective. Military flight simulators in Fleet use now incorporate various levels of automated fidelity test (AFT) capability ranging from none to relatively sophisticated. The lack of consistent AFT capability is a recurring problem in the acquisition and modification of Navy and Marine Corps flight training simulators. It forces excessive and sometimes contentious use of expensive manual methods during development and throughout the life cycle. A new set of tools that make up a universal AFT design is needed to ensure that consistent and comprehensive validation test capabilities are built into all flight trainers.

PHASE I: Determine how a set of new, innovative software tools can interface or reside on the host computer systems found on military flight simulators and will execute automated fidelity validation tests. The intent is to make it easy to incorporate these test tools into the overall design of new simulation systems and to retrofit them into existing legacy flight simulation systems. The extent of interface with the various simulator systems, including the cockpit components, should be analyzed and considered in the design approach with the goal of maximizing the flexibility of the AFT applications. The automated test drivers must apply correct flight test methods, be easily tunable via user friendly editing features, and address both fixed-wing and rotary-wing simulator applications. Data analysis methods and data recording output must be automated but easily modified to fit the criteria data situation.

PHASE II: Construct a prototype universal AFT that will be capable of executing a full flight envelope validation test on a Navy or Marine Corps fixed-wing or rotary-wing flight training simulator. Interface the universal AFT with more than one existing training simulator and demonstrate its capability and flexibility.

PHASE III: The universal AFT may be packaged as two separate products: one for fixed-wing and another for rotary-wing applications. An additional development effort in this phase could include the automation of the test driver algorithm tuning process so that the AFT will be more readily adaptable to new aircraft simulator applications. The universal AFT can be applied to various applications to include a) validation of flight simulators that are under development (i.e, JSF), b) validation of flight simulators used in support of flight test, c) acceptance testing of man-in-the-loop flight simulation Fleet trainers, and d) flight simulators that are going to participate in networked test or training exercises in order to define player capabilities and fair fight guidelines. Strong training system program candidates for this technology include the F/A-18 and the XH-60X programs.

PHASE III DUAL USE APPLICATIONS: A universal AFT system would be useful for all users and developers of flight simulators. This research program will demonstrate that system interface issues for various simulators are not a problem and will facilitate broad application. The universal AFT system can be packaged as a PC based software tool that can be used for new simulators, thereby reducing the risk associated with developing custom automated test routines from scratch. A universal AFT system developed to test military flight simulators, both fixed and rotary wing, can be easily adapted to FAA simulator qualification test processes for civilian applications. Additionally, there is a direct extension of the universal AFT to validation testing domains outside the flight domain that would include ship simulations.

KEYWORDS: Validation, Flight Fidelity, Flight Test, Automated Test, Flight Simulator, Flight Training

N02-186 **TITLE:** High Energy, Lightweight, Sealed Lead Acid Battery for V-22 Applications

TECHNOLOGY AREAS: Air Platform

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT ID: PMA 275 - V-22 (Osprey) Program

OBJECTIVE: Develop innovative techniques to reduce sealed lead acid (SLA) battery weight with emphasis on the reduced weight of grids, increased use of active materials, and increased service life.

DESCRIPTION: The battery currently used on V-22 aircraft for auxiliary power unit (APU) starting and essential battery bus powering will support the Fleet for many years. Research is needed to reduce this SLA battery's weight while maintaining its capacity of 24 ampere-hours (A-hr), with a weight-reduction goal of 10 to 15 percent. The V-22 battery charge voltage can be as high as 29.0 volts, with a maximum of 250 amperes for 5 minutes and 200 amperes for continuous operation from the regulated converter. Any new grid construction innovations/materials in the monoblock area and the increased use of existing materials must address V-22 service requirements, including vibration requirements. The mechanical layout is to be consistent with the current battery mounting, footprint, and connector location. The novel approach should also increase service life to 4 years while maintaining the 18-month shelf life.

PHASE I: Assess the feasibility of the lightweight design via the introduction of new materials in certain areas of the system such as the monoblocks and the grids. The assets do not have to be optimized in Phase I, as to the type of lightweight material for the substrate, thickness of the substrate, or the thickness and makeup of any coatings. Phase I should only report the results of the evaluation and establish an optimization and development plan for materials and construction. This plan should also address processes for joining the new materials to the current carrying post and to the external connector, with material compatibility concerns addressed.

PHASE II: Develop prototype assets from various lightweight materials, at different thicknesses for the substrate, various coatings and coating thicknesses and coating various alloys. These will be tested to existing battery specification requirements to verify electrical, dynamic, and mechanical performance and to verify the weight saving goals. Perform a shelf-life study to assure that there is no migration of material and that batteries are recoverable after deep discharge. Build a prototype battery (configured to the current battery specifications D8565/7-2) for MIL-PRF-8565 type electrical testing to confirm compliance with the specification. Deliver one battery to be used for initial qualification testing.

PHASE III: Manufacture batteries to complete qualification testing and to support flight evaluation. Transition the innovative, lightweight batteries to the V-22 production line. Provide Fleet support as well as spares and replacements for those aircraft currently in use.

PHASE III DUAL USE APPLICATIONS: Lead acid batteries are the world's most widely used battery type. Commercial aircraft can achieve up to $3,000 savings for fuel cost per aircraft per year for every pound that is removed. Lighter batteries will enable other products such as hybrid-electric vehicles for military, civil automobiles, and transportation vehicles.

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KEYWORDS: Sealed Lead Acid Battery, Grids, Active Materials, Monoblocks, Auxiliary Power Unit, Essential Battery Bus

N02-187 **TITLE**: Abrasion-Resistant, Electrically Conductive Transparent Coatings for Polycarbonate

TECHNOLOGY AREAS: Materials/Processes

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT II: PMA 234 - A-6/EA-6 Program

OBJECTIVE: Develop optically transparent materials that are electrically conductive, can be applied to aircraft transparencies, and will increase the resistance to abrasion, scratches, and chemical attack of the transparency.

DESCRIPTION: Polycarbonate materials used in the transparency system of military aircraft have a stack up of coatings to protect the material from the environment. A single multifunctional layer is desirable because it would improve the manufacturing process by reducing the risk of manufacturing defect, reduce cost, and increase the life of the transparency system. An electrically conductive material is sought that can be applied to polycarbonate aircraft transparencies and improve the resistance of the transparency to impact damage, scratching, and chemical attack.

PHASE I: Identify state-of-the-art protective materials that can be used as a single multifunctional protective layer on polycarbonate transparency materials that could replace the current stack up of protective coatings. Material selection should be based on (1) light transmission, (2) haze, (3) conductivity, (4) abrasion, (5) chemical resistance to operational solvents and wind screen cleaning materials (such as Plexusâ), and (6) adhesion properties of the materials as applied to polycarbonate substrates. Develop processes to apply the material to the outer surface of the polycarbonate. Demonstrate improved performance in abrasion and chemical resistance without degradation to physical mechanical or optical properties of the base materials. Polycarbonate test substrate should follow AMS-P-83310 requirements. Assess properties before and after exposure to accelerated weathering. Evaluate the conductivity using analysis and test.

PHASE II: Demonstrate compatibility with current manufacturing processes and actual transparency shape, size and curvature. Refine the manufacturing processes. Evaluate the protective materials' optical capability, conductivity, abrasion, and chemical resistance on actual transparencies and wind screens.

PHASE III: Scale up protective material and application process to meet production requirements for military aircraft transparencies.

PHASE III DUAL USE APPLICATIONS: Protective materials and processes developed from this SBIR could potentially benefit commercial aircraft, automobiles, and other vehicles.

KEYWORDS: Polycarbonate, Transparency, Abrasion, Coating, Wind Screen, Chemical Resistance

N02-188 **TITLE:** Detection-Driven Useful Life and Performance Life Remaining Prognostic Models for Aircraft Disk and Blade Propulsion Turbo Machinery

TECHNOLOGY AREAS: Air Platform

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT I: Joint Strike Fighter

OBJECTIVE: Develop and demonstrate useful life and performance life remaining prediction models, advanced prognostic models, statistical techniques, and other programs that can be used to relate accurate useful life remaining predictions for various types and degrees of faults and failures on aircraft engine disks, blades and blisks.

DESCRIPTION: To enable fully the predictive part of any prognostic and health management (PHM) concept, there has to be the capability to relate detected incipient fault conditions, with load conditions, to accurate useful life remaining predictions for any point in time along the failure progression. The key to accomplishing this is to understand incipient fault-to-failure progression characteristics for aircraft disk, blade and blisk used in propulsion machinery and to have realistic and verifiable prognostic models. It is recognized that disk and blade failure mechanisms and the understanding of the fault to failure progression characteristics are unique to their application and are different than other aircraft components. Therefore, the resulting techniques, tools and prognostic models will be unique to the disk and blade design for aircraft propulsion machinery application. In a modern turbo machinery blisk design, where the blades and disks are one integral unit, failure mechanisms are more complicated and present unique challenges to understanding progression failure characteristics. Accurate useful life remaining predictions may be accomplished through merging of an understanding of the physics of failure, real-time detection technology, analytical and physical models, statistical techniques, and actual failure data. Some level of real-time sensors and/or measurable state awareness must be input into the prognostic models and techniques. Interaction modeling between the blades and the disk will also be required.

PHASE I: Define the techniques and processes needed to detect fault conditions within disks, blades, and blisks; and relate useful life remaining predictions to these conditions. Develop a plan to develop and integrate the various innovative tools, models, statistical techniques, and other required programs. Demonstrate the feasibility of the detection system, prognostic models and supporting programs to determine useful life remaining on a specific aircraft engine application. Develop an initial list of required inputs to the models. Develop a strategy for implementing a specific application.

PHASE II: Develop and demonstrate a prototype for the interaction between the detection system and the prognostic models, techniques, tools and programs on the selected engine and specific components. Demonstrations will occur on a rig demonstration or on an actual engine test coordinated by the Navy. Demonstrations will support a “blind test” to validate the models and assess the application boundaries, accuracy, and limitations for these modeling techniques. Develop, validate, and deliver a complete prototype system of detection means, application of prognostic models, and techniques to be used on the proposed aircraft application. Models will be developed to run on a standard PC platform and optimized to use minimal computing resources.

PHASE III: Finalize these models with a major aircraft or engine manufacturer. Integrate these models into a baseline PHM configuration of the selected engine.

PHASE III DUAL USE APPLICATIONS: These advanced models would provide a good baseline for alteration to fit any other aircraft engine as well as a power plant application. Any results gained from applying these detection methods and failure progression rate models will provide a significant crossover benefit to other similar applications, commercial or military.

REFERENCES:
1. SAE E-32 Committee Documents
2. ISO TC/SG5 Draft Standards
3. IEEE Aerospace Conference Proceedings for 2001 and 2002 Track 11 PHM

KEYWORDS: Diagnostics, Prognostics, Modeling, Useful Life Remaining Predictions, Prognostics and Health Management, Failure Prediction

N02-189 **TITLE**: Multi-Sensor Information Fusion and Information Visualization

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT I: Joint Strike Fighter

OBJECTIVE: Develop multi-sensor information fusion and information visualization methods and techniques for time-critical decision-making specifically focusing on the capability and capacity of pilots operating in modern, single-seat cockpits.

DESCRIPTION: The wealth of sensor information derived from both imaging and non-imaging sensors is creating pilot workload issues. In time-critical situations, the amount of information can be overwhelming to the pilot and, in fact, adversely affect the decision process. This wealth of information can include synthetic aperture radar (SAR) imagery, inverse synthetic aperture radar (ISAR) imagery, electro-optical/infrared (EO/IR) imagery, moving target indication (MTI), target status (detection, location, classification, identification, etc.) data confidence levels, weapon status, sensor platform position, and weather conditions. Some work has been directed toward the combination and visualization of multi-source information. Yet, there is little understanding of precisely how and what type of information must be fused (combined) to support the pilot in truly time-critical decision processes. Particular emphasis must be placed on the representation/display of the multi-source information. This is to minimize information overload and to stress information that must be comprehended by the pilot for successful prosecution of the mission. The aim of this research is to analyze the types of information generated by the individual contributing sensor suite and identify optimal use/exploitation of the fused data. This research will also address automated, tailorable target and tactical data/information prioritization and three-dimensional visualization techniques to represent/display the selected information to the pilot.

PHASE I: Identify and prioritize data/information sources that contribute to pilot decision processes. Conduct research that leads to fusion of different information sources. Explore innovative concepts for exploiting the combination and fusion of data derived from imaging and non-imaging sources. Include the exploitation of contextual information (e.g., roads, terrain features) derived from imagery to gain additional information about fused entities (targets) in the tactical situation. Explore fusion functionality for determining the relationships among multiple entities detected by disjoint sensors exploiting disjoint information sets. Establish display and three-dimensional visualization techniques and characteristics that provide the pilot with time-critical information that includes target characteristics, target priority, weapons, and sensor availability.

PHASE II: Further refine algorithm approaches, characterize overall performance, and possibly balance the algorithms against operational requirements. Demonstrate and validate the performance of information fusion and display techniques developed in Phase I to include user evaluation and instrumented performance improvement studies that analyze timeline reduction of the decision-making process.

PHASE III: Integrate full capability into a modern, single-seat aircraft.

PHASE III DUAL USE APPLICATIONS: This capability can be applied to the commercial market sector in a wide range of applications that can include emergency control centers, law enforcement, traffic control, and manufacturing process control.

KEYWORDS: Multi Sensor, Information Fusion, Information Display, Visualization, Time-Critical Decision, Pilot Workload

N02-190 **TITLE:** Efficient Numerical Methods for Stable Distributions

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT I: Joint Strike Fighter

OBJECTIVE: Model stochastic processes associated with avionic sensors by stable distribution to improve signal extraction and processing.

DESCRIPTION: Univariate and multivariate stable distributions have significant modeling advantages for more accurately modeling the interfering clutter and noise associated with radio frequency (RF)/optical sensors. Although their modeling flexibility is significant, their density and distribution functions are not in closed form, which militates against their application. Moreover, the numerical representations of these distributions are notoriously difficult and this topic is a current significant area of research. Nearly 75 years after their derivation, efficient numerical algorithms are starting to yield to the persistence of researchers in the last decade and, with the current embedded microprocessor power that has exploded in the last 5 years, the modeling power of these distributions can be unleashed on the problems of signal extraction and estimation in the sensor environment. The Navy is seeking a collection of the currently known numerical methods, new methods to solve further problems associated with the class of distributions, and a deliverable C++ package of self-contained routines that can be used by sensor designers to apply to their problems.

PHASE I: Develop a specific set of methods for efficient, fast, and accurate calculation of all the various distributions, densities, parameter estimates, and associated problems with both univariate and multivariate stable distributions. Those distributions may not be limited with sum stable distributions since product stable, max stable, and other distributions may have their use as well. Topics to be addressed should include but not be limited to the following:

1. Calculation of the probability density functions (PDFs) and cumulative distribution functions (CDFs) associated with all the alpha-stable distributions.

2. Estimation of all the parameters for all the cases.

3. Estimation of best stable model with saturated or truncated sample information, which limits the observability of the samples.

4. Effects of quantization on the sample distribution and estimates of all parameters.

5. Distribution of functions of stable random variables such as the magnitude and other instantaneous, possibly nonlinear, functions of the data such as the locally most powerful (LMP) detector.

6. LMP estimators associated with alpha-stable samples and samples from functions of transformed alpha-stable variates.

PHASE II: Develop and deliver a coherent, user-friendly portable C++ software package addressing all the problems related to the stable distributions. Document fully the software and numerical techniques and supply them as part of the software system. Demonstrate through non-real-time analysis, with an existing radar data set, that modeling with stable distributions has the potential of significantly upgrading the range and sensitivity of RF systems such as synthetic aperture radar (SAR) and search radar.

PHASE III: Transition technology to one of the major Navy radar development programs. Demonstrate, real-time with hardware in-the-loop, the improvements of alpha-stable distributions.

PHASE III DUAL USE APPLICATIONS: Stable distributions have been applied to the stock market, astronomy, economics, and biology, as well as communications and radar. Potential applications include acoustic and RF sensors. Any software package resulting from the SBIR may be of some interest to applications software companies, although this area is so specialized that there is no current mass market. However, as this modeling becomes more available to image and signal processing environments, the demand for this software should grow. The derivation of the numerical procedures is very difficult and involved, and once created, the capabilities will be in high demand within the modeling community. Such capabilities should provide a potential market in computer vision and image processing associated with sensors, manufacturing systems, communications systems, and queuing systems.

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2. R. Adler, R. Feldman, and M. Taqqu, Editors, A Practical Guide to Heavy Tails, Birkhauser, Boston, 1998.
3. V. Zolotarev, One-dimensional Stable Distributions, Math. Monographs, Vol 65, AMS, Providence, RI, 1986
4. C. Nikias and M. Shaw, Signal Processing with Alpha-Stable Distributions and Applications, John Wiley, NY, 1995.

KEYWORDS: Stable Distributions, Alpha-Stable Distributions, Levy Distribution, Numerical Algorithms, Non-Gaussian Estimation and Detection, Quantization Effects on Random Variates

N02-191 **TITLE:** Interface between Image Generator and Display

TECHNOLOGY AREAS: Human Systems

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT I: Joint Strike Fighter

OBJECTIVE: Develop a general use interface (hardware and software) that improves performance of visual display systems for real-time immersive trainers. For existing visual flight trainer systems, this includes allowing existing data bases and image generators (IGs) to be used while improving transport delay, load management, and possibly fidelity while at the same time allowing for replacing projectors with low-cost, high-performance digital projectors. For new systems, this includes cost-effective improvement of visual system performance.

DESCRIPTION: Database compatibility issues seriously impede upgrading visual display systems. A hardware interface between the IG and display projectors could allow the use of existing database/IG solutions while at the same time allow increased flexibility and performance. Low-cost personal computer (PC) based IG solutions do not provide for geometry distortion correction, edge blending, etc. This necessitates the use of high-cost projectors and low-brightness cathode ray tube (CRT) projectors for many applications. Low-cost PC-based IG solutions also do not provide for effective load management locked synchronization of multiple channels. This eliminates the consumer grade low-cost IG from contention in many cases. High-end IGs solve these problems but they are expensive and they are not being redesigned to take advantage of the latest integrated circuit manufacturing technology (due to economies of scale). As a result, a low-cost solution to provide these features is needed that can be applied to any existing and future IG running any database. The solution must not restrict current IG designs and their associated databases.

Multiple proposed solutions will be considered. An example follows. An interface has the potential to provide all the distortion correction, pixel brightness adjustments, and filtering that would allow independent design teams to solve these issues without having an impact on their IG and database. It also has the potential to provide an effective overload management approach by allowing reuse of IG output images by shifting the image to compensate for the current orientation of the trainee in the simulated virtual world. This reuse of IG images would allow an alternative to "skipped frames" from the IG when it is overloaded. It would also allow for the IG to update at lower rates, thereby allowing much higher fidelity images to be created. Image shifting could also allow reduction of transport delay by compensating for changes in orientation of the trainee at the last stage of the pipelined process.

PHASE I: Demonstrate effectiveness of the proposed solution to meet the given objective. Demonstrate the feasibility of how the proposed solution will work around graphics board/computer hardware limits and how it will effectively work with run time software. Include details on how an existing IG running an existing database would be easily adapted to run higher fidelity using the interface.

PHASE II: Design, develop, and prototype the solution. Demonstrate the solution on a visual system that is run real time.

PHASE III: Refine the Phase II hardware/software to be an industry useful solution that is easy to learn/use and is documented.

PHASE III DUAL USE APPLICATIONS: Real-time, high-performance simulation, such as flight trainers for commercial aviation.

KEYWORDS: Simulation, Imaging, Visual, Data Base, Real Time, Trainer

N02-192 **TITLE**: Automatic Extrusion of Surface Features from Terrain Aerial/Satellite Imagery

TECHNOLOGY AREAS: Human Systems

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT I: Joint Strike Fighter

OBJECTIVE: Develop an automatic interpretive capability that determines location and orientation of terrain surface features and provides automatic population of terrain databases with surface models matching these features.

DESCRIPTION: Database creation has become a big expense for visual simulation of geospecific real-world environments used in real-time simulation training. It also has become the major limiting factor in allowing effective use of new low-cost real-time graphic image generation hardware. Satellite imagery used for creation of three-dimensional models of parts of the world is now commercially available down to 1-meter resolution. Aerial photo imagery is available to even higher resolution. This allows creation of high-fidelity geospecific database models of geographic areas of the world. However, three-dimensional models of surface features such as trees and buildings must be placed on top of the topographic surface such that they match the terrain image. Currently, this can be accomplished by hand but is man-hour intensive and error prone. Only the most crucial areas are modeled correctly. This process needs to be automated to reduce cost, improve quality, and reduce turn-around time required for creating geospecific databases. Also, as computer graphic capability increases, the number of surface features that can be computed in a real-time simulation trainer increases. This drives the need for databases with more terrain surface features, which in turn drives the need for an effective automated process. The need exists for an automated tool that meets the peculiar needs of the real-time simulation training community. Other types of information about terrain surfaces could also be used to complement the interpretation process; however, the location and orientation of all surface features placed in the database must match the locations and orientations of the underlying terrain imagery. Also, the proposed approach must consider the limitations of real-time image generators as well as cost/availability of source imagery and source data, and usability in the real-time training simulation industry. The process should also identify the type materials of the surface features so database support for accurate sensor image simulation is provided.

PHASE I: Provide a proof-of-concept demonstration that includes effectiveness of at least one important interpretive algorithm using actual satellite/aerial imagery. Demonstrate incorporation of the solution into a visual database, which is run real time. Determine feasibility of how the proposed solution will work around graphics board/computer hardware limits and how it will effectively work with run time software.

PHASE II: Add additional interpretive algorithms, which improve the quality. For example, match the feature location, orientation, and appearance to the ortho-rectified terrain surface image for many feature types under difficult lighting and obscuration conditions. This may include creating a reference library of surface models and a library of model types, which are adjustable to better match individual features. Develop a prototype to demonstrate the automated tool's ability to create or improve a visual database to meet a training need.

PHASE III: Refine the software used to accomplish Phase II to be an industry useful software tool. This may include improving robust functionality, make it easier to learn, and use documentation.

PHASE III DUAL USE APPLICATIONS: Real-time, high-performance simulation, such as flight trainers for commercial aviation. All users of aerial photography for land management and city planning would benefit. (i.e., forestry, road planning, tax assessment, etc.).

KEYWORDS: Simulation, Imaging, Visual, Reconnaissance, Data Base, Training

N02-193 **TITLE:** Leak Detectors in Aircraft Systems

TECHNOLOGY AREAS: Air Platform

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT I: Joint Strike Fighter

OBJECTIVE: Develop a sensor that will detect fluid leaks in the hydraulic, fuel, and cooling systems, identifying the leak location, type of fluid, and leakage rate.

DESCRIPTION: The sensor should be able to detect fluid presence and increases in fluid quantity over time (so as to distinguish between standing fluid and leaks), and should report leaks only, as well as their location and rate of leakage. The sensor should be able to distinguish between all fluids commonly found on an aircraft (including brake fluid, hydraulic fluid, fuel, water, coolant, etc.). All data computing and integration should occur on board the aircraft. All leaks should be reported to the maintenance interface panel (MIP) and portable maintenance aid (PMA). Each report should include fluid location, leak rate, and fluid identity. The sensor configuration will be optimized so that its volume should not exceed the cube of one diameter of the line, which it is designed to monitor. A method of installation will need to be developed so that installation of an individual sensor does not exceed 15 minutes, and the sensor should be retrofitable on legacy aircraft.

PHASE I: Establish the feasibility of all candidate processes that could be implemented to perform fluid detection and identification. Select one technology that can best perform the required task, keeping in mind size, weight, and affordability of the final product. Develop a preliminary software and hardware architecture that will convert the technology into a useful tool. The architecture must include sensor configuration (for ease of installation) as well as a method of data collection, processing, transmission, and storage. The architecture must make provisions for a wireless transmission to the aircraft health assessment system (e.g., air vehicle manager).

PHASE II: Further define the sensor configuration and architecture. Construct and test a working prototype in the laboratory that includes wireless transmission of information. The sensor should be fitted and proven to work on an aircraft in flight.

PHASE III: Commence with full production of the sensor. Also determine other platforms on which to implement this technology, besides the aerospace application, and seek dual-use applications for this technology.

PHASE III DUAL USE APPLICATIONS: This technology could be used to detect leaks in major mechanical and thermal systems in industrial applications. The development of the sensor, combined with wireless transmission of health maintenance reports, could provide for affordable remote monitoring of critical machinery in the commercial sector.

KEYWORDS: Fluid Detection, Sensor, Leakage Rate, Leaks, Aircraft Health Monitoring, Condition-Based Maintenance

N02-194 **TITLE:** Fiber Placement Process Expert System

TECHNOLOGY AREAS: Materials/Processes

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT I: Joint Strike Fighter

OBJECTIVE: Enable fiber placement customers and producers to determine the impact of changes to the fiber placement process and optimize their risk reduction testing.

DESCRIPTION: Fiber placement is an advanced composite fabrication process being used on next-generation aircraft and spacecraft programs. The fiber placement process is not a single process with standardized variables and parameters, but a collection of processes that continue to evolve at a rapid rate with continuous changes in equipment, design and controlling software, and materials. This enables continuing improvements in quality, reduced recurring costs, and increased complexity of parts that can be made by fiber placement. On the downside, however, the same changes are not being made at all manufacturers' facilities at the same time. Additionally, as changes in the fiber placement process are made, a certain amount of requalification testing is necessary to ensure that there are no detrimental effects on the parts being made by that specific manufacturer. Currently, each aerospace system and/or fiber placement manufacturer establishes its own set of tests on a case-by-case basis. This is time-consuming and expensive, and there are no shared lessons learned.

The proposed program should establish the influence of various attributes and attribute interactions on the fiber placement process. These attribute relationships will be incorporated into an expert system and validated via mechanical testing, software verification, and part fabrication. The desired expert system could be used as a uniform approach for assessing changes to the fiber placement process, which include but are not limited to new equipment, various types of process modifications, software upgrades, material changes, and new technology infusion. This would reduce the time and cost of test planning, cost of required testing, and risk of process changes. Companies submitting proposals must have an excellent understanding of the fiber placement process in a production environment and structural requirements of composite materials in aerospace applications.

PHASE I: Identify a preliminary list of attributes and attribute interactions that affect the fiber placement manufacturing process. Define requirements for a standardized approach for assessment of changes within the fiber placement process. Identify features needed in the expert system to ensure general applicability within the aerospace industry. Establish a preliminary (limited) expert system. Use expert system to predict possible attribute influences, then perform screen testing to validate predictions.

PHASE II: Develop prototype expert system. Verify the effects of attributes/attribute interactions in the fiber placement process by mechanical testing, numerically controlled (NC) software demonstration, and manufacturing trials. Demonstrate the expert system on at least two industry-related applications.

PHASE III: Implement use of the expert system on an aerospace acquisition platform. The basic approach could be modified for other manufacturing processes such as high-speed machining and resin transfer molding.

PHASE III DUAL USE APPLICATIONS: Easily transferable to commercial aerospace applications that use or could benefit from the use of fiber placement such as the D609 commercial tiltrotor, commercial space payload fairings, Boeing 777, business jets, and helicopters. Fiber placement is also used in the automotive, chemical processing, construction, sports equipment, and other industries. The proposed technology is applicable to any of these industries, but especially structural applications.

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KEYWORDS: Fiber Placement, Composites, Attribute Interaction, Expert System, Manufacturing, Process Parameter

N02-195 **TITLE:** Fault-to-Failure Progression Modeling of Propulsion System and Drive Train Bearings for Prognostic and Useful Performance Life Remaining Predictions

TECHNOLOGY AREAS: Air Platform

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT I: Joint Strike Fighter

OBJECTIVE: Develop and demonstrate incipient fault-to-failure progression models, advanced prognostic models, statistical techniques, and other programs that can be used to relate accurate useful life remaining predictions for various types and degrees of fault and failure conditions in propulsion system and drive train bearings.

DESCRIPTION: In order to fully enable the predictive part of any prognostic and health management (PHM) concept, there has to be some capability to relate detected incipient fault conditions to accurate useful life remaining predictions for any point in time. The key to accomplishing this is being able to understand incipient fault-to-failure progression characteristics for propulsion system and drive train bearings; and developing realistic and verifiable prognostic models for useful life remaining predictions. This may be accomplished through the merging of the physics of failure, analytical models, physical models, statistical techniques, and actual bearing failure data. It is recognized that bearing failure mechanisms and the understanding of the fault to failure progression characteristics are unique to their application and are different than other aircraft components.

Therefore, the resulting techniques, tools and prognostic models will be unique to the bearing application. Some level of real-time sensor and/or measurable state awareness will be a required input to these prognostic models and techniques. This effort will develop, demonstrate, and apply these innovative advanced prognostic and useful life remaining models in support of the predictive part of PHM on rolling element bearings and their components.

PHASE I: Define the techniques and processes needed to relate useful life remaining predictions to detectable fault conditions in propulsion system and drive train bearings and their components. Report on a strategy to develop the advanced models, statistical techniques, and other programs required. Establish and demonstrate the feasibility of the proposed techniques, tools and models to predict accurate useful life remaining.

PHASE II: Develop, demonstrate and validate a prototype for these advanced models, tools, techniques, and programs for a specific propulsion system and drive train bearings. Assess the application boundaries, accuracy, and limitations for these modeling techniques. Show the potential to integrate these capabilities with a comprehensive PHM system.

PHASE III: Finalize these models with a major aircraft or engine manufacturer. Apply these modeling programs on a new aircraft development program like the JSF.

PHASE III DUAL USE APPLICATIONS: These advanced models would be applicable to any propulsion system and drive train application that will be applying diagnostic, prognostic, and health management capabilities. Any results gained from applying these failure progression rate models to particular propulsion system and drive train bearings will provide a significant crossover benefit to other similar applications, commercial or military.

REFERENCES:
1. SAE E-32 Committee Documents
2. ISO TC/SG5 Draft Standards
3. IEEE Aerospace Conference Proceedings for 2001 and 2002 Track 11 PHM

KEYWORDS: Diagnostics, Prognostics, Modeling, Useful Life Remaining Predictions, Prognostic and Health Management, Failure Prediction

OFFICE OF NAVAL RESEARCH (ONR)

N02-196 **TITLE:** Systems Optimization for an Integrated Ocean Thermal Energy Conversion (OTEC) Plant

TECHNOLOGY AREAS: Materials/Processes, Sensors, Electronics, Battlespace

OBJECTIVE: Develop a innovative systemic approach for optimally evaluating and developing economically feasible Ocean Thermal Energy Conversion (OTEC) facilities which integrate the ancillary technologies available to tropical island based military installations and/or civilian communities.

DESCRIPTION: An integrated systems approach has never been implemented in evaluating the economic feasibility of OTEC technology. Only the economic merits of the power producing components have been addressed when analyzing and comparing to more conventional energy systems. Previous analyses have completely ignored the additional economic, social and environmental benefits an integrated systems approach incorporating ancillary technologies can provide. Recent advances in the power-cycle and cold-water pipe (CWP) materials and deployment technologies have greatly reduced initial capital costs and risks commonly associated with and currently hindering the effective commercialization of OTEC.

PHASE I: Design a systems optimization computer/mathematical model which utilizes key site-specific input variables necessary to develop a commercial sized, integrated OTEC facility. This facility could incorporate energy and fresh water production, seawater air conditioning and provide potential aquaculture applications.

PHASE II: Develop an OTEC plant design utilizing the systems optimization algorithm for an existing tropical island naval/military base. Create a realistic, commercially viable OTEC plant design utilizing available site data and incorporating appropriate ancillary system technologies desirable for the specific military mission requirements.

PHASE III: Apply the systems optimization and analysis design procedures by actualizing the commercial development of integrated OTEC system(s) in tropical island based naval/military installations and/or civilian communities/governments in suitable ocean environments.

PHASE III DUAL USE APPLICATIONS: Any tropical island community with reasonable access to the necessary cold-water resource is a potential benefactor of the systems approach to OTEC development. The need for consistent, predictably affordable baseline power, potable fresh water and the other economic, social and environmental benefits of an integrated system is nearly universal throughout the tropical ocean community.

REFERENCES:

1. Avery, W.H., and Chih, W., 1994. Renewable Energy from the Ocean – A Guide to OTEC, Oxford University Press, New York.
2. Ericksen, T.L., Smith, D.A. and Krock, H.J, Proceedings of the U.S. Navy and Industry Symposium on OTEC, Kailua-Kona, Hawaii, December 4-5, 1996.

KEYWORDS: OTEC, Systems, Optimal, Integrated, Energy, Tropical

N02-197 **TITLE:** Four-dimensional (4-D) Oceanographic Instrumentation

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

OBJECTIVE: Develop low-weight, low-power, and low-volume instruments/sensors/techniques to autonomously measure oceanographic parameters.

DESCRIPTION: Innovative sensors and measurement techniques are solicited to obtain oceanographic variables (e.g., physical, chemical, optical) in 3-D space and time. The emphasis should be placed on (1) novel approaches and concepts for measuring a particular parameter coherently in 4-D, (2) observations which can be conducted as autonomously as possible (i.e. for independent operation on Remotely Piloted Aircraft (RPA), Autonomous Underwater Vehicles (AUV's), ships, buoys or with expendable instruments), (3) providing a significant reduction in instrument weight, volume and power without reducing fidelity or resolution as compared to current state-of-the-art devices, (4) developing the next generation of low cost, potentially expendable instrumentation usable in both navy operational scenarios as well as in S & T environmental data collection, and (5) developing enabling technologies for operating equipment/acquiring data in extreme environments (e.g., manipulations at depth or in extremely hot or cold conditions). Examples of some of the types of instruments solicited include: instruments to measure standard variables (conductivity, temperature, wave height/period) over wide areas, instruments to measure optical properties, the next generation of low cost oceanographic expendable instrumentation, or the accurate measurement of temperature, humidity, winds, and wave properties near the surface in extreme conditions. The term Expendable Instrumentation includes both one time usage as well as long time in situ usage and the sensors should be affordable if expendability is required but reusable if not. Included are instrumentation development efforts that would result in significant improvements in sensitivity or reliability and cost savings for existing expendable instrumentation, or would develop new expendable capabilities for measurements currently obtainable by other means, or would significantly expand the range of utility of existing techniques (as, say, under the ice). All platform deployment scenarios are included and expendables can be launched, dropped, drift, etc. Priority is given to devices and methods that can lead to substantial improvements in ship self-defense, airstrike targeting and special operations, through improved battle space environmental knowledge.

PHASE I: Provide both an exact description of the parameter to be measured including accuracy and sensitivity along with the instrument design concept for achieving the measurement.

PHASE II: Produce a viable prototype system and demonstrate its ability to support field measurements from an appropriate platform.

PHASE III: Transition the technology to scientific use in the atmospheric, oceanographic or environmental monitoring research communities, and operational DOD systems.

PHASE III DUAL USE APPLICATIONS: New instruments can be used in a wide variety of commercial environmental monitoring systems.

REFERENCES:

1. Rapid Environmental Assessment, SACLANTCEN Conference Proceedings Series CP-44, E. Pouliquen, A.D. Kirwan, Jr., and R.T. Pearson, eds., NATO SACLANT Undersea Research Center, La Spezia, Italy, 1997.

KEYWORDS: Oceanography, Instruments, Miniaturize, Automation, Expendable

N02-198 **TITLE:** Sensor Technology for Anti-Submarine Warfare

TECHNOLOGY AREAS: Sensors, Battlespace

OBJECTIVE: Development of advanced sensor technology to support future anti-submarine warfare (ASW) sensor systems.

DESCRIPTION: The focus of this SBIR topic is to stimulate bold new concepts for undersea sensor systems that will be effective against anticipated year 2020 threats. Threats include quiet submarines and multiple smaller quiet targets, such as UUVs. The sensor systems will be responsible for, or support surveillance, reconnaissance, cueing, targeting, tagging and neutralization operations. While these future generations of sensor systems will be aboard ships and submarines they will also be part of miniature autonomous fixed and mobile nodes. The systems will require high performance micro-sensors for effective operation. Particular interest is in the areas of micro-magnetometers, active and passive acoustic, and seismometer sensor systems. However, novel concepts that exploit other signature phenomena are also of interest. Important performance parameters are sensitivity and accuracy, response to the variable of interest, efficiency of operation and ruggedness. Performance is required in shallow water littoral regions where significant environmental and man-made noise may obscure the threat signature. Sensor concepts that provide resistance to disruption or damage from commercial trawling and dredging are of interest as well.

PHASE I: Develop and document a sensor concept or physics based sensor model describing the theory of operation and predicted performance of the sensor in an operational environment.

PHASE II: Fabricate and test a breadboard (experimental) prototype of the sensor and provide clear and complete documentation of the prototype's final design, functionality, and testing conducted to demonstrate performance.

PHASE III: Design, fabricate and test advanced developmental prototype sensor.

PHASE III DUAL USE APPLICATIONS: There is a commercial market for advanced sensor technology. The technology developed in this SBIR could be of use in a wide range of applications outside the military.

REFERENCES:

1. MARELEC Marine & Electromagnetics Conference Proceedings, 11-13 July 2001, Stockholm, Sweden.
2. Military Sensing Symposia, Battlefield Acoustic and Seismic Sensing, Magnetic and Electric Field Sensors, 23-26 October 2001, Laurel, Maryland.

KEYWORDS: Electromagnetic, Acoustic and Seismic Sensors, Signal Processing, Multitarget Tracking, State Estimation, Common Tactical Picture

N02-199 **TITLE:** Unmanned Underwater Vehicle (UUV) Obstacle Avoidance Sonar (OAS) Algorithms

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: United States Special Operations Command (USSOCOM), ACAT level IV T SAM

OBJECTIVE: Develop algorithms that can be incorporated into a UUV platform to enable obstacle detection and autonomous path planning decisions using affordable, low power obstacle avoidance sensors.

DESCRIPTION: Small UUVs operating in the very shallow water regime typically fly at altitudes of a few meters. Thus, they are susceptible to collision with large rocks, reefs, mines, obstacles or any other object of a few meters in altitude. Obstacle avoidance sonars are needed to increase the ability to complete missions in this environment. Key to OAS algorithm development is modeling to develop an understanding of how a small UUV platform can respond to a detected obstacle establishing the relationships between speed of advance, keep-out volume and autonomous controller/hydrodynamics. This understanding enables selection of the appropriate commercial off-the-shelf OAS or establishes criteria for a developmental effort. With selection of the appropriate sensor, the model incorporating the autonomous controller can be used to develop and test obstacle avoidance algorithms, ultimately leading to demonstration in a UUV platform.

PHASE I: Model development incorporating UUV autonomous controller behavior to establish OAS performance parameters.

PHASE II: Continuation of model development and selection of OAS hardware leading to demonstration on a UUV platform of algorithms that autonomously detect the presence of small obstacles or larger geographic features and adaptively path plan to avoid while minimizing mission deviation.

PHASE III: Implement a production OAS system for use by small UUVs in civilian and military work environments.

PHASE III DUAL USE APPLICATIONS: This system could be applied in any undersea search/survey operations where a small UUV is required.

REFERENCES:

1. Navy Unmanned Undersea Vehicle (UUV) Master Plan, April, 2000 commissioned by PEO-USW, PMS-403 http://www.onr.navy.mil/02/baa/baa01_012/PIP/uuvmp.pdf

KEYWORDS: UUV, Sonar, Underwater, Detection, Algorithms, Modeling

N02-200 **TITLE:** Maritime Intelligence, Surveillance, Reconnaissance (ISR) and Space Exploitation

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

OBJECTIVE: Develop and demonstrate autonomous signal processing and data fusion technology that can improve littoral battlespace awareness for Naval forces conducting anti-submarine warfare (ASW) and/or mine countermeasure (MCM) missions.

DESCRIPTION: The focus of this SBIR topic is to stimulate bold new concepts to enable ASW and MCM commanders utilizing maritime ISR assets to see and understand the littoral battlespace with greater fidelity and reduce the time it takes to shape the battlespace. The presence of many neutral surface ships of all sizes and purposes as well as friendly and enemy combatants, including mines complicate the battlespace. Methods of detecting and classifying (or, in some cases, identifying) neutrals (commercial shipping, fishing and pleasure craft) and unusual threats such as small surface craft (i.e. "Boghammers") and small submarines (diesels or mini-submarines) is critical. Novel means of exploiting information from sensors, including space-based sensors are of interest. Techniques that facilitate the real-time detection and characterization of distinctive signatures obscured by environmental and/or man-made noises are of particular interest. Methods of detecting, localizing and tracking entities of interest in the complex littoral environment are sought. The ultimate goal is to maintain a consistent awareness of the battlespace among warfighters who are dispersed and intermittently in contact with each other. Related interests include improved specification of environmental parameters affecting signal detection to include techniques and sensors for ionospheric specification and novel techniques for ionospheric and atmospheric remote sensing such as bistatic GPS.

PHASE I: Develop a complete algorithm or detailed description of the proposed ISR concept. The algorithm, description, or design and supporting documentation should be sufficient to convince qualified engineers that the proposed concept is technically feasible.

PHASE II: Produce and demonstrate performance of a computer program based on the algorithm or description of the concept. Demonstrate performance in such a way as to convince qualified engineers that the proposed concept is capable of meeting requirements in an operational environment.

PHASE III: Working with the Office of Naval Research and certain Navy Systems Command Offices, integrate real-time algorithms into existing and/or future ASW or MIW ISR systems.

PHASE III DUAL USE APPLICATIONS: There is a commercial market for ISR technology. The technology developed in this SBIR could be of use in a wide range of applications outside the military.

REFERENCES:

1. S. M. Kay, Fundamentals of Statistical Signal Processing: Estimation Theory. Englewood Cliffs, NJ: Prentice-Hall, 1993.
2. S. M. Kay, Fundamentals of Statistical Signal Processing: Detection Theory. Englewood Cliffs, NJ: Prentice-Hall, 1998.
3. D. L. Hall and J. Llinas, "An Introduction to Multisensor Data Fusion" IEEE Proceedings, pp. 6-23, Jan. 1997.

KEYWORDS: Electromagnetic, Acoustic and Hydrodynamic Signatures, Signal Processing, Multitarget Tracking, State Estimation, Common Tactical Picture

N02-201 **TITLE:** Tactical Decision Aid Model Upgrades

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: Develop a tactical decision aid to integrate high fidelity modeling and simulation (M&S) tools and tactical exploitation algorithms for ASW and submarine vulnerability applications.

DESCRIPTION: Modern high fidelity modeling and discrete event simulation based Tactical Decision Aids permit rapid development and testing of algorithms, mission planning, and operational procedures in scenarios characterized by complex phenomenology and multiple agents. This effort seeks to explore new and creative technologies, algorithms, and computational methods to model and simulate scenarios for use in evaluating ASW potential and submarine vulnerability, especially to in situ and remote sensors. These should include accurate signature and clutter models that account for the important platform structural and operational parameters and that correctly describe detectability in realistic environments representative of both open ocean and littoral scenarios. The desired tools should address all important sensor modalities and should account for realistic background clutter environments as sources of false alarms and missed detections. They should include Monte Carlo or similar capability to allow statistical evaluation of random target, searcher and environmental factors. An interactive mode is desired, including an option for multiple players, to support algorithm and tactics development.

Although Tactical Decision Aids (TDAs) have been developed previously whose purpose is to aid mission planners, they are based on models, some of which now are known to be quite inaccurate. These tools must be improved to reflect state-of-the-art modeling that permits the accurate assessment of wake visibility in a wide range of situations and includes dependence on relevant signature and environmental clutter parameters.
This effort will address the following topics:

- Identify the components of existing TDAs that require improvement.
- Review state-of-the-art models for implementation in the TDA. Some limited model development may be necessary.
- Implement the upgraded models in software, which should be accessed through a user-friendly interface
- Demonstrate that the TDA predictions are consistent with government-provided data.
- The software should provide probability of detection at a user-specified false alarm rate for each of the modeled sensors.

PHASE I: Determine the deficiencies and define the desired upgrades to existing TDAs. Review state-of-the-art signature and clutter models for remote sensing of the ocean from microwave to optical wavelengths. Compare the performance of these models with ones used in existing TDAs and quantify the errors and uncertainties associated with each remote sensor that is modeled. In Phase I, select one sensor for improved modeling and develop efficient software for performance predictions. Demonstrate that the predictions are consistent with data and represent an improvement over existing tools. Outline how this model can be implemented/substituted into existing TDAs, with attention to providing both maximum flexibility with respect to diversity of operations and environment and minimum complication demanding substantial operator training and experience.

PHASE II: Implement the above model and all others requiring improvement in an existing TDA. These algorithms should be driven by a graphical-user-interface (GUI) that can be used in a mode that is minimally complex, but has ¡§drill-down¡¨ capability by sophisticated users, who may need to explore in detail the model dependence on all the relevant environment and sensor parameters. The TDA should output probability of detection at a user-defined false-alarm rate. The TDA should be optimized for the most efficient application as a mission-planning tool.

PHASE III. Transition the TDA software to mission planners and search aircraft. These tools would be valuable for DOD prime contractors developing future ASW systems, and submarine patrols will be able to use commercial remote sensors to detect wakes, when environmental parameters indicate that such systems provide high detection probabilities.

PHASE III DUAL USE APPLICATIONS: These tools would be valuable for the large security and surveillance industry, law and drug enforcement, Immigration Services, Coast Guard, and Homeland Defense. These agencies could use the TDA for port security, training and search of Littoral waters.

KEYWORDS: Tactical Decision Aids, Modeling and Simulation, Decision-making, Sensors, Information Uncertainty, Physics-Based Modeling, Multi-Source Information

N02-202 **TITLE:** Improved Body Armor

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Develop a better body armor ceramic material through incorporation of metal wires, ribbons or other materials. The incorporated materials may hold the ceramic material together and provide other benefits.

DESCRIPTION: Ceramic inserts are often used in body armor. One wants to obtain the greatest possible benefit of the ceramic in mitigating the effects of an incoming projectile or use thinner, lighter materials that provide benefits equivalent to those of thicker materials. There is some reason to believe that combinations of materials could provide benefits over and above solid ceramics. This could include means to prevent pieces of ceramic from being ejected, means to increase the contact and grinding action and means to provide increased dissipation caused by the ceramic as it interacts with the incoming projectile. An added material could also benefit the mechanical properties of the ceramic. Metal wire or ribbons could hypothetically cause such benefits. The metal wires or ribbons would have to be compatible with the ceramic material fabrication. Alternative added materials are also possible. Also it might be possible to improve the ceramic plate response (shatter/fracture mechanics) while negatively affecting backface response. The ceramic could be Boron Carbide or an alternative.

PHASE I: Define a system (or systems) to improve ceramic body armor through incorporation of metal wire, ribbons or other material in the ceramic. Show by calculation and/or simple experiments that improvements will be obtained. Provide the metric or standard for ‘improvement’ here (e.g., reduced energy transmissibility through the plate or reduced backface deformation).

PHASE II: Optimize the material parameters in the system (or systems) and provide a detailed design (or designs). Fabricate sample components and test compared to conventional components to show superiority. Show effects on both primary and secondary impact wave transmission and on backface deformation. Optimized material parameters for the production system should be stated in terms of reduced weight/bulk with transmissibility equal to or below boron carbide, or enhanced dissipation of energy/reduced backface deformation with equal system mass. Evaluate performance characteristics of ceramic materials in extremes of temperature and humidity combinations.

PHASE III: Demonstrate producibility and develop an implementation plan for production. Design and develop methods for production-scaled end item. Demonstrate that the production systems meet or exceed NIJ standards for Ballistic Resistance of Personal Body Armor (NIJ 0101.04 Rev. A, or successors). Develop logistics support requirements (deterioration, plate durability in transport, integration with existing soft armor protective systems, degradation of performance during storage in environmental extremes). Develop an implementation plan including estimated cost to procure/maintain production items for deployment with forces. Prepare technology transition packages with appropriate service Program Offices detailing integration, production, and supportability.

PHASE III DUAL USE APPLICATIONS: Use by police and other law enforcement personnel.

REFERENCES:

1. United States Patent 5,456,156, Oct 10 1995.

KEYWORDS: Body Armor, Armor, Ceramics

N02-203 **TITLE:** Biomimetic Image Processing for Air-Surface Weapons

TECHNOLOGY AREAS: Sensors

OBJECTIVE: Develop biomimetically-inspired image processing suitable for use with an uncooled focal-plane array of infrared detectors. This array is to be used in an air-to-surface weapon.

DESCRIPTION: The goal of this project is to apply the recent advances in understanding of the neurology of insects (principally flies) to the problem of processing images in modern infrared weapons seekers. Flying insects offer an attractive model for processing of images gathered by rather low-pixel-count imagers. In spite of the relative coarseness of their optical systems, flies have a remarkable ability to identify, track, and close on moving (including flying) targets in the midst of a wide variety of natural clutter, and the goal of this project is to bring those benefits to air-to-surface imaging seekers.

Specific requirements: For an imaging sensor that utilizes a commercially-available 240 X 320 pixel uncooled infrared focal-plane array (FPA), develop an insect-inspired signal processor that can begin with signals derived from the subject FPA and its attendant, commercially-available readout electronics. Assume the FPA frame-rate is between 30 and 60 Hz, inclusively. The air weapon moves at about 600 ft/sec, and the ground target at about 60 ft/sec in a random fashion, turning no faster than a typical pickup truck. The signal processor can be digital, analog, or a judicious combination of digital and analog electronics. The degree to which the chosen algorithms mimic biologically-inspired processing will be a major selection factor. The biomimetic algorithms must be robust enough to operate in natural clutter, optical flow, and must identify the targets of interest.

PHASE I: Select an appropriate insect model for which there is a body of research on optical processing in the insect brain. Describe mathematically and with detailed block and circuit diagrams the algorithm(s) proposed to solve the problem stated above. This description must be of sufficient detail and quality that a weapons signal processing engineer can understand how the algorithm will be applied in the air-surface weapon.

PHASE II: Reduce the proposed algorithms to circuit designs that can be fabricated in a standard commercial silicon foundry. Cause the circuits to be produced. Prepare a test plan that will demonstrate in the laboratory the performance of the biomimetic circuits using images from a focal-plane array camera operated in the visible spectrum (for example, using a conventional CCD camera). Evaluate and report results.

PHASE III: Execute field tests of an appropriately designed sensor unit. Tests should use commercial helicopter platform to carry the signal processor and the camera. Ground targets should travel at a variety of speeds, executing turns, and traveling in different natural and manmade environments. Environments used must include desert areas of southwest USA. Test must include single target, multiple targets, and single target with non-targets.

PHASE III DUAL USE APPLICATIONS: Biomimetic algorithms for tracking moving targets will find application in manufacturing as industrial robots are designed to operate in less structured plant environments, tracking parts and partially completed manufactured units. The algorithms and camera designs will also aid law enforcement in following suspects in natural environments. Biomimetic systems may also be used in flight situations involving autonomous, unmanned air vehicles.

KEYWORDS: Biomimetics, Flies, Algorithms, Moving Targets, Air-to-Surface, Signal Processing

N02-204 **TITLE:** Small Undersea Unmanned Vehicle Forward-Looking/Near-Nadir Sonar

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: United States Special Operations Command (USSOCOM), ACAT level IV T

OBJECTIVE: Enable development of a conformal array to provide near-nadir and forward-looking sonar coverage that can be integrated with side-scan sonar for a small undersea unmanned vehicle (UUV) being used in bottom search/survey operations.

DESCRIPTION: Side-scan sonar technology has been demonstrated as a useful tool for undersea bottom search/survey operations. A small UUV capable of operating in very shallow water leaves a coverage gap of approximately two meters between the two side-scan array coverage envelopes, and has no ability to look forward for obstacle avoidance. A near-nadir sonar (NNS) will fill in these gaps, increasing area coverage rate, and significantly reducing total time required to survey a given area. It is also desired that the array have the ability to raise the angle of view to provide both near-nadir and forward-looking sonar (FLS) coverage to provide an obstacle avoidance capability when coupled with appropriate software routines within the UUV processors.

PHASE I: Develop conceptually a FLS/NNS system capable of meeting the size and power limitations posed by a small (7.5" diameter) UUV housing, operating at low power levels (less than 17 watts). Additionally, the sonar system should able to be integrated with the vehicle's current side-scan sonar arrays for processing.

PHASE II: Once determined feasible, demonstration of FLS/NNS system integration into a vehicle with size and power limitations will be demonstrated through the manufacture of hardware prototypes. Associated with the Phase II proof of concept is software development that utilizes appropriate algorithms in order to achieve obstacle detection and avoidance capabilities on-board an underway UUV moving at 2.5-4kts at an altitude of approximately 3 meters. Testing will be required to ensure FLS/NNS obstacle detection/avoidance and compatibility with side-scan sonar and on-board computer aided detection/classification system.

PHASE III: Upon completion of the prototype demonstration, the production FLS/NNS system will be implemented into small UUVs in military work environments.

PHASE III DUAL USE APPLICATIONS: This system could be applied in any undersea search/survey operations where a small UUV is required.

REFERENCES:
1. "Object Identification with Acoustic Lenses" Ed Belcher et al, Proceedings of IEEE Oceans 2001.
2. "VSW MCM using the REMUS AUV" Roger Stokey et al, Proceedings of IEEE Oceans 2001.

KEYWORDS: Sonar, Underwater, Search, Survey, Detection, Classification, Analysis, Forward-Looking, Gap-Filler and Near-Nadir.

STRATEGIC SYSTEMS PROGRAMS (SSP)

N02-205 **TITLE:** Effects of Built In Self Test (BIST) Circuitry on System Electronics in a Radiation Environment.

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: Strategic Systems Programs, ACAT Level I

OBJECTIVE: Using design automation, mitigate performance degradation of Built In Self Test (BIST) circuits subjected to a radiation environment.

DESCRIPTION: The purpose of this effort is to: 1) determine the performance deficiencies of BIST circuitry in a selected electronics system exposed to a radiation environment; 2) develop design concepts that will mitigate these deficiencies; and 3) incorporate these design concepts into an appropriate Electronic Design Automation (EDA) tool. The concern is possible adverse effects in different radiation environments (Total Ionizing Dose (TID), Single Event Effects (SEE) and Prompt Dose) on electronics with BIST circuitry. During exposure to these radiation environments, transistor performance is degraded and charges are generated in all active circuits. Increasing financial and performance goals have driven the electronic industry to integrate more functionality onto single substrates with transistor counts in the millions. These complex designs must be tested after production as well as throughout their entire service life, yet classical external test approaches are not practical. BIST circuitry is more practical for modern complex electronics and provides faster, easier testing with greater fault coverage. However, the use of BIST may increase an electronics system’s degradation due to radiation. Before BIST is used in an electronics system that may encounter a radiation event, measures must be taken to insure that the BIST design will not unacceptably degrade the overall system’s performance and reliability. This involves considerable risk since there are no validated or automated tools to provide such a capability. The key technology areas include an accurate underlying model of radiation effects on electronics, mitigating circuit design measures, and a suitable EDA that can be adapted to an effective concept.

PHASE I: Select an electronic system or component with BIST and an appropriate commercial EDA tool that will be used for the development effort. Develop an innovative feasibility concept that provides a radiation hard design capability for BIST circuitry, and incorporate this concept into the selected commercial EDA tool.

PHASE II: Evaluate the BIST circuitry to identify design issues related to the radiation environment specified above. This may be done using computer simulations, laboratory testing or any other valid approach. Design circuitry that eliminates undesired effects. Conduct a prototype demonstration to verify the design. Provide documentation needed to integrate redesign methodology into the selected EDA tool.

PHASE III: Strategic Systems Programs will use the interface requirements identified by the small business in phase II, to design strategic level military electronics using commercial EDA tools. Furthermore, as new radiation hard design methods become available the small business may develop additional interface requirements.

PHASE III DUAL USE APPLICATIONS: This capability would be useful in the commercial satellite industry, aerospace and other areas of defense where there is a need for modern control, sequencing and interlock radiation hard electronics. One example would be to radiation-harden modern telecommunication satellites that make extensive use of large-scale integrated circuits with BIST. This capability will enable the use of commercial electronics data and design tools in the design of strategic grade electronics.

KEYWORDS: BIST, Radiation, EDA, Reliability, SEE (Single Event Effects), TID

N02-206 **TITLE**: Wireless Umbilical System

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: Strategic Systems Programs, ACAT Level I

OBJECTIVE: To develop a communication and power system architecture that eliminates hardwire umbilical connections between the missile and platform while providing secure, reliable power and communications.

DESCRIPTION: Future submarine launched missiles will be totally encapsulated requiring that the capsules not be penetrated even for electrical power or electronic signal connections. The automotive industry is developing electric cars that utilize inductive coupling for vehicle charging. Impressing a data signal on the power signal, so that the data communication might also be inductively coupled is, perhaps, one approach. There are significant interrelated issues that must be resolved in concert to achieve this capability including: (1) assuring that nearby energetic material could not inadvertently be initiated; (2) satisfactorily maintaining data rates for communication between the submarine and the missile; (3) providing adequate power transfer to the missile; (4) ensuring that physical separation clearance between the submarine and capsule is compatible with the communication and power transfer; and, (5) verifying the integrity and electromagnetic compatibility between the power transfer and the communication signals. The simultaneous solution of these issues requires new and innovative approaches and R&D.

PHASE I: Create a feasibility concept that offers the potential to provide inductive power and a wireless data link between the submarine and the capsule; and that would establish the critical design parameters. This will include bi-directional data communication between the submarine 1553 data bus and the candidate missile computing system; power distribution from the submarine 270 VDC bus to the candidate missile power bus; and diagnostics monitoring of the inductive interconnection.

PHASE II: Based on the feasibility concept of Phase I, fabricate a wireless umbilical system prototype. Conduct a demonstration of this prototype to define performance capabilities and possible electromagnetic compatibility issues with candidate platform/payload systems.

PHASE III: Develop a standardized interface structure/protocol to support candidate encapsulated missile systems. Conduct design, engineering, integration of this capsule – submarine wireless umbilical system, and install it on a candidate platform/payload system.

PHASE III DUAL USE APPLICATIONS: The is currently the leader in developing and applying wireless technologies. Yet, they have not been able to eliminate the volume of inconvenient, unsightly and cumbersome cables that run between DVDs/VCRs and televisions, and between computers and their peripherals. Cableless interconnections would provide a significant market advantage in these areas over existing systems. Further, the technology could be extended and applied to interconnection within instrumentation systems, electric vehicles, and portable electronic devices.

REFERENCES:

1. http://www.mesasystemsco.com/inpud_overview_head.html
2. EA Technology Homepage, Inductive Coupling Mechanisms for Charging Electric Vehicles, 13 August 2001

KEYWORDS: Wireless, Communications, Electromagnetic, Inductive, Coupling, Encapsulated

SPECIAL ANTI-TERRORISM TOPIC (ONR)

N02-207 **TITLE:** Anti-Terrorism - Technologies for Asymmetric Naval Warfare

TECHNOLOGY AREAS: Air Platform, Chemical/Bio Defense, Information Systems, Ground/Sea Vehicles, Materials/Processes, Biomedical, Sensors, Electronics, Battlespace, Space Platforms, Human Systems, Weapons, Nuclear Technology

OBJECTIVE: Develop technologies that offer enhanced capabilities to Naval forces engaging a terrorist or other asymmetric enemy force.

DESCRIPTION: The proposed technology should enhance the ability of Naval forces to anticipate, prepare for, recognize, survive, and retaliate against a terrorist or other asymmetric attack. Any approach that offers such an enhanced capability will be considered. The proposed technologies should be available within five years. Proposals must include R&D, be innovative, have a level of technical risk and not be a procurement of existing product or technology. In general, capabilities in one or more of the following four sub-topic areas are sought:

1. DETECTION, INDICATIONS, AND WARNINGS: Technologies that offer Naval forces advance warning of terrorist or other asymmetric attack: as examples, in-port surveillance systems for ships, surveillance against asymmetric threats in littoral regions, tactical intelligence capabilities for Marines operating in urban areas, sea-based intelligence capabilities for Naval forces in a terrorist threat environment, advanced models that support meteorological and oceanographic forecasting and now casting in the maritime battlespace for predicting transport of threat agents, novel threat and identification characterization techniques including social and behavioral indicators, etc. Among other priorities the Naval services are interested in technologies that offer enhanced situational awareness, physical security, or force protection capabilities that enhance the security Naval facilities and forward-deployed forces while reducing the number of personnel that would otherwise be required to achieve an equivalent level of security.

2. SURVIVABILITY AND DENIAL: Technologies that offer enhanced capabilities to prevent, preempt, or survive a terrorist or other asymmetric attack: as examples, armor enhancements for ships, improved shipboard damage control (including blast mitigation and fire-fighting), less-than-lethal systems to deny enemy access to Naval units and other assets, advanced design concepts for Naval platforms optimized for asymmetric warfare, mine countermeasures, etc. Among other priorities the Naval services are interested in technologies that offer enhanced protection of ships, port facilities, and other high-value afloat assets against terrorist or other asymmetric attack. A technology proposed along these lines should enhance the security of Naval forces afloat and the port and harbor facilities that support them.

3. CONSEQUENCE MANAGEMENT AND RECOVERY: Technologies that enhance the ability of forward-deployed forces to fight-through and recover from a terrorist or other asymmetric attack and the capability of Naval facilities to contend with a terrorist event. Such technologies may include but are not limited to: advanced emergency medical technologies (particularly treatments for shock and burns, and for chemical, biological, or radiological injury), chemical, biological, and radiological decontamination technologies for shipboard use, continuity of operations following attack by weapons of mass destruction, etc.

4. ATTRIBUTION AND RETALIATION: Technologies that enhance the ability of forward-deployed forces to determine the source of a terrorist or other asymmetric attack and to deliver effective retaliation against that source. Such technologies may address but are not limited to: enhanced special operations capabilities for Marine Air/Ground Task Forces, precision targeting (particularly of moving and other short-dwell-time targets), technologies for avoiding blue-on-blue and blue-on-white engagements, enhancements to Naval strike capabilities (particularly against weapons-of-mass-destruction production and storage facilities, and against hard and deeply buried targets), enhanced sea-based fire support for Operational Maneuver from the Sea, etc.

The Navy expects to receive many proposals under this topic and make between 15 to 40 Phase I awards. To assist in the review process it is requested that the small businesses include the sub-topic area as part of the proposal title and list the area of science or technology that will be used as the first line of the abstract. This will help us to disseminate the proposals to the right technology area reviewers. It is important that the small business write a strong abstract that clearly defines the specific area being addressed, summarizes the technology to be used and describes how the company will accomplish the phase I effort. The full proposal should follow using the sections as defined in this solicitation and also define the problem being addressed.

PHASE I: Develop an innovative, cost-effective design for a technology that promises a significant contribution to Naval capabilities against terrorism and other asymmetric threats.

PHASE II: Prove the concept by delivering a working prototype of the technology.

PHASE III: Transition to advanced development of a full-up design and/or production package.

PHASE III DUAL USE APPLICATIONS: Technologies developed in response to this desired capability offer multiple opportunities for commercial exploitation.

REFERENCES:

1. United States Commission on National Security (http://www.nssg.gov/index.html).
2. Expeditionary Maneuver Warfare (Headquarters, United States Marine Corps, 10 Nov 01).
3. Vision, Presence, Power (http://www.chinfo.navy.mil/navpalib/policy/vision/vis00/top-v00.html).
4. "Meeting the Homeland Defense Challenge: Maritime and Other Critical Dimensions", CNO remarks at the Institute for Foreign Policy Analysis and the Fletcher School of Law and Diplomacy, Cambridge, MA 26 March 2002 (http://www.chinfo.navy.mil/navpalib/cno/clark-speeches.html)
5. "Setting Our Course in the Terror War", Remarks by CNO at the Naval War College Symposium, Naval War College, Newport, R.I., 29 October 2001 (http://www.chinfo.navy.mil/navpalib/cno/clark-speeches.html)

KEYWORDS: Anti-Terrorism, Armor, Medical Technologies, Biological Technologies, Retaliation, Precision Targeting, Sensors